A Summary of Current Program and
Preliminary Report of Progress

SHEEP AND WOOL RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

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ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil & Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Clothing and Housing
3 - Consumer & Food Economics
4 - Market Quality
4 - Transportation & Facilities
7 - Animal Husbandry
7 - Animal Disease & Parasite
12 - Crops
12 - Entomology

Economic Research Service, (ERS)

4,5 - Marketing Economics
5 - Farm Production Economics
5 - Resource Development Economics
5 - Economic & Statistical Analysis
5 - Foreign Development & Trade Analysis
5 - Foreign Analysis

Other Services

4,5 - Farmer Cooperative Service (FCS)
4,5 - Statistical Reporting Service (SRS)
6 - Forest Service (FS)

SUBJECT MATTER PROGRESS REPORTS

The other type of report brings together the U.S.D.A. program and progress for the following commodities or subjects:

3 - Rural Dwellings
6 - Forestry (other than Forest Service)
7 - Beef Cattle
7 - Dairy
7 - Poultry
7 - Sheep and Wool
7 - Swine
7 - Cross Specie and Miscellaneous Animal Research
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Citrus and Subtropical Fruit
10 - Deciduous Fruit and Tree Nut
10 - Potato
10 - Vegetable
10 - Florist, Nursery & Shade Tree
11 - Oilseeds and Peanut
11 - Sugar
13 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C.

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INTRODUCTION

This report on sheep research covers work directly related to the production, processing, distribution, and consumption of sheep, lamb, wool, goats and mohair. The information has been assembled from the organizational unit reports of the several divisions. This report does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only sheep problems but also to the problems of other commodities. Progress on cross-commodity work is found in the reports of the several divisions such as Soil and Water Conservation, Human Nutrition, Transportation and Facilities, Farm Production Economics, Foreign Development and Trade Analysis, and Cross-Specie and Miscellaneous Animal Research.

This report is devoted to the 19 "problem areas" shown in the table of contents. For each area there is a statement of (1) the Problem, (2) the USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) a summary of Progress during the past year on USDA and cooperative work, and (5) a list of Publications resulting from USDA and cooperative work.

Sheep research can be divided into three major categories, i.e., that supported by (1) Federal funds appropriated to the research agencies of the United States Department of Agriculture, (2) Federal and State funds appropriated to the 53 State Agricultural Experiment Stations, and (3) private funds allotted, largely by the sheep industry, to research carried on in private laboratories or to support of State Station or USDA work. For all three categories it is estimated that about 300 scientists are engaged in research dealing specifically with the production, processing, distribution, and consumption of sheep and wool. Support of their work involves an annual expenditure of between 7 and 10 million dollars. This amounts to about 1.0 percent of the cash farm receipts from sheep and wool and about 0.5 percent of the retail value of meat and wool. Of the 300 scientists engaged in sheep and wool research, approximately 33% are employed by the Department of Agriculture, 25% by the State Experiment Stations, and 42% by other universities, foundations, and private industry.

Research by USDA

Farm research pertaining to sheep and wool is conducted in the Agricultural Research Service divisions of Agricultural Engineering, Animal Disease and Parasite, Animal Husbandry, and Entomology. The work comprises investigations of breeding, physiology, nutrition, diseases, parasites, housing and management, involving 43 professional man-years of scientific effort.

Nutrition, consumer, and utilization research pertaining to sheep and wool is conducted in the Agricultural Research Service divisions of Human Nutrition, Consumer and Food Economics, Clothing and Housing, Eastern Utilization and Western Utilization. The work on meat comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. Work on wool pertains to fabric and textile performance. Research pertaining to the processing phase involves slaughtering the animals and processing the meat and the wool. Also, it is concerned with improved equipment and processes. The work in these divisions involves 39 professional man-years of scientific effort.

The utilization research in meat processing and products, animal fats and oils, and hides, skins, and leather which involves more than one specie - and if done with one specie may be applicable to others - is discussed in "Cross Specie and Miscellaneous Animal Research" progress report.

Marketing and economic research pertaining to sheep and wool is carried on within four Services: Agricultural Research Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing; and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, ARS; Transportation and Facilities, ARS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; Standards and Research, SRS. The scientific effort involved by these divisions amounts to 10 professional man-years.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects sheep and wool research is carried on by most experiment stations in States where sheep and wool are important. The types of work to which the largest amount of effort is devoted include efficiency of production, diseases and parasites, and marketing. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

The production research conducted by industry is done primarily by large commercial ranches in the West and pharmaceutical manufacturing companies. The size of flocks needed and effort involved for evaluating breeding practices has rested largely with publicly supported institutions, and with the cooperation of owners of private herds. The effects of hormone and hormone-like substances alone or in combination with antibiotics on growth and physiological reaction of sheep is being studied by a few pharmaceutical companies.

The research in utilization and marketing conducted by industry, which is applicable to sheep, goats, wool and mohair, is not clear cut. The animals and their products are merged with other species and products at auction and terminal markets in processing plants, and on through the marketing channels, and research emphasis pertains more to functions than commodities.

With mill consolidation in recent years industrial research on wool has practically disappeared. With the advent of synthetic fibers what was formerly a wool-processing industry lost interest in wool per se and undertook processing of the particular fibers that were in demand. Processors of the synthetics conducted the research needed to adapt the wool machinery to process synthetics and provided the information to the industry. This development in combination with a serious decline in the financial strength of the wool industry resulted in a shift of scientists from wool research to quality control, mill troubleshooting and short-range developmental work. Industry application of research developed by public institutions is done where it has a potential of profit.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Crossbreeding increases lamb production. Birth weights, weaning weights, and gain from birth to weaning were generally higher for crossbred than for purebred matings at Beltsville, Maryland. Crosses of Hampshire, Shropshire, Southdown, and Merino sheep showed increases over purebreds of 7 lbs. for weaning weight. Pounds of lamb weaned per ewe bred, obtained by combining reproductive rates with weaning weights, were 6 lbs. greater for 2-breed crosses than for purebreds. Three-breed crosses exceeded 2-breed crosses by 12 lbs. and 4-breed crosses exceeded 3-breed crosses by 8 lbs. Thus, crossbreeding led to large increases in pounds of lamb produced per ewe.

Malformation in lambs and calves caused by poisonous plants. The conditions known as "monkey face" in lambs, and the so-called "crooked calf" disease were long thought to be inherited. Our scientists have shown that these conditions result from toxic fetal insult during early pregnancy. In the case of the "monkey face" in lambs, a cyclopian-type malformation, the toxic agent is the plant Veratrum californicum (false hellebore, wild corn, skunk cabbage). Ewes

ingesting this plant on the 13th and 14th day of pregnancy produce malformed lambs. Continued ingestion beyond the 14th day causes an increased number of fetal deaths. In the case of the "crooked calf" syndrome, the fetal insult is caused by wild lupines. This work is similar to, but predates the discovery that the drug Thalidomide could cause malformed babies.

Stiff lamb disease. Wisconsin and Utah workers have discovered that a condition of sheep previously of unknown cause and referred to by livestockmen as "stiff lamb disease" is caused by a virus. The disease is now known as "Polyarthritis." Utah has found that Polyarthritis is widely distributed in sheep in the Western Mountain area and can cause serious outbreaks of a similar disease in calves. Workers are now concentrating on efforts to provide methods for Polyarthritis control in sheep and calves.

WURLAN-treated wool yarn in commercial production. Three U. S. companies began this past year producing yarns treated with the ARS process for shrink-proofing wool fabrics. This "WURLANized" yarn is used for knit goods that combine the natural advantages of wool with the easy-care performance of synthetics, plus other desirable properties important to consumers. Producers claim that these yarns are "dependably washable by any normal method, truly resistant to shrinking and felting, more resistant to abrasion, have improved tensile strength, retain the look and feel of wool, and exhibit no weight loss and no loss in chemical resistance." WURLAN-treated fabrics are being produced at a steadily increasing rate, which is now well over one million yards annually. The extension of the treatment to yarn greatly expands the application of the Department's discovery to a wide variety of knitted structures which otherwise could not be treated. The WURLAN treatment is thus playing an important role in improving the competitive position of wool through providing goods which are machine-washable.

Instrument developed for measuring elastic recovery of fabrics. Investigations now underway on the elastic recovery of cotton, wool, and WURLANized wool knit fabrics have resulted in the development by CH staff of a simple instrument for measuring this property. The new apparatus releases the Clothing and Housing Research Division's more expensive and versatile electronic equipment for other uses, yet gives comparable results. Because of its simplicity and successful performance, details concerning its construction and use are expected to be of interest not only to Department scientists studying performance of fabrics used in clothing and household textiles, but also to others whose work in research or in quality control involves measurement of elastic behavior.

New facilities for handling meat and poultry in New York City. As a result of studies by the Transportation and Facilities Research Division, ARS, an additional $40 million complex of facilities is being planned for handling meat and poultry, for which the New York City Board of Estimate has allotted $6.1 million for site acquisition and design. The facilities are being planned adjacent to the new $36 million fruit and vegetable facility that is under construction at Hunts Point and will replace the 14th Street and Brook Avenue Markets. Total annual saving in handling fruits, vegetables, meat, and poultry in new facilities is estimated to be almost $25 million.

Improving pooling and pricing methods of marketing cooperatives. A study of lamb pooling showed that there are 235 agencies providing this service and that farmers received from 50 cents to $5 per hundredweight more than if lambs had been sold individually in small ungraded and nonuniform lots.

Consumers' opinions of natural fibers. Results of studies conducted by the Special Surveys Branch, Standards and Research Division, Statistical Reporting Service, on consumers' opinions of agriculturally-produced materials in various end uses have been used by natural fiber organizations to evaluate the position of cotton and wool in specific segments of the textile industry, and to encourage and guide private industry's efforts to improve the attributes of natural fibers so that they can compete more successfully with synthetics. In addition, each year the National Cotton Council of America bases a major portion of its promotion for consumers and retailers on these research results; these reports have also been used as standard examples in the market development program of Cotton Council International.

I. FARM RESEARCH

SHEEP AND GOATS - BREEDING
Animal Husbandry Research Division, ARS

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding and selection need to be tested. Breeding studies on reproductive efficiency, inheritance of feed efficiency, rate of gain and carcass, as well as wool quality, deserve emphasis.

USDA AND COOPERATIVE PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons and studies of gains resulting from crossing of breeds. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Cooperation is maintained with 16 State experiment stations. Several of the studies contribute to the western, southern and north central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 6.2 professional man-years. Of this number 1.4 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Research in sheep and goat breeding seeks information needed for the most rapid genetic improvement of these species. Genetic investigations with sheep include carcass characteristics, wool production, reproductive capacity, performance and progeny testing, selection methods and criteria, early lambing, breed and breed-cross performance, genotype x environmental interactions, development of superior strains and management. Wide ranges in breeds are included in several of the studies permitting estimation of genetic variation which occurs between breeds to be utilized in crossing programs and in breed selection. Greater reproductive capacity is of primary concern in many of the studies, and efforts are being made to increase multiple births, improve frequency of pregnancy, and eliminate seasonal breeding. Frequently this approach to greater reproductive rate

is from the genetic aspects or combination of genetics with other disciplines such as nutrition, physiology, or management. In several of the Southern States, for example, early season breeding to produce lambs is being approached through genetic improvement, hormonal treatment, and temperature control.

Research is conducted also under three regional projects; S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South; W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep; and NC-50, Improvement of Lamb Meat Production Through Breeding.

Active USDA cooperation in sheep breeding investigations is limited to a few State stations and representation of the USDA on technical committees of regional projects.

Genetic investigations with Angora goats for mohair production are being conducted at the Texas station. Evaluation of four selection methods is being made, and estimates of heritability of economic traits and interrelations between traits are being developed.

The total research effort on sheep and goat breeding research by the State agricultural experiment stations is 23.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Interactions affecting weanling and yearling traits. Interactions affecting 39 weanling and yearling traits of Rambouillet, Targhee and Columbia ewes and rams were studied. These interactions included all combinations between age of dam, sex, years, type of birth-rearing, band in which raised, and type of mating. Interactions between years and type of birth were significant for 12% of the tests and years and band were significant for 24% of the tests. It was found that only a small percent of the yearling traits were affected by the interaction between mating system and type of birth or age of dam. Only a few significant interactions were found to exist between sex and age of dam and sex and type of birth. Ewe lambs tend to be superior to ram lambs in a poor environment but inferior in a good environment. The traits most often affected by interactions were weanling condition (27% of tests over 11 interactions) yearling width of body score (25% of tests over 6 interactions) and weanling weight (23% of tests over 11 interactions). All other traits were affected in less than 20% of the tests which included all available interactions. (AH b1-6)

2. Heritabilities and correlations in weanling and yearling traits. Heritabilities, phenotypic and genetic correlations were studied among 39 fleece and body traits of weanling and yearling Rambouillet, Targhee and Columbia ewes. Heritabilities between 30% - 70% were obtained for weanling

face cover, index, birth weight, and staple length and for yearling face cover, body type, body condition, staple length, fiber crimp, fiber diameter, clean fleece weight, grease fleece weight, scored body width and height at withers. Only a few estimates were above 70% and a few below 30%. There was no difference in estimates obtained from inbred or noninbred groups. The highest positive genetic correlations were found among the various fleece characteristics, especially those describing fiber fineness and between body traits describing body size. Genetic correlations between fleece and body traits were generally low. Genetic correlations between the same traits as weanling and yearling age showed face cover, body weight and staple length to be high, while those involving thigh grade, belly wool, and average daily gain were very low. Other correlations were generally moderate to low. The most important negative genetic correlations were those between yearling variability of fiber diameter and staple length, clean fleece yield and grease fleece weight, thigh grade and staple length, thigh grade and clean fleece weight, side grade and staple length, side grade and clean fleece weight, and staple length and fiber diameter measured in several areas of the fleece. The above correlations were generally of a magnitude exceeding -.45. (AH b1-6)

3. The effect of sire on composition of lamb fat. The effect of sire on the composition of ovine fat was studied on fat samples from 180 lamb carcasses. These lambs originated at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, New Mexico, and fattened at New Mexico State University. The fat analyses were carried out at Colorado State University. The analyses revealed that sires had a significant effect on iodine numbers and melting point. Heritabilities of these two traits were found to be 0.31% and 0.33%, respectively. Sex and type of birth had no effect on fat composition of the lambs. (AH b1-10, 11, 12)

4. Relation of growth rate of lambs to carcass composition. A study was conducted at Fort Reno, Oklahoma, to evaluate the influence of different growth rates of lambs on carcass composition involving sixty crossbred milk fat lambs out of Dorset X Western ewes and Western ewes mated to Dorset, Hampshire, and Suffolk rams. It was found that the earlier maturing, slower gaining white-face lambs were fatter by 3.4%, had 1% less bone, 2.4% less lean, and required 23 more days to reach slaughter weight of 100 lbs. than the blackface lambs. Twin lambs averaged 1.6% more fat, 0.8% less lean and 0.8% less bone than singles. (AH b3-7)

5. Repeatability of lamb growth. Repeatability estimates of birth weight, 70 day weight and rate of gain from 70 to 140 days of age were calculated on 829 lambs from Rambouillet and Rambouillet X Panama-Rambouillet ewes born over a 6-year period at Fort Reno, Oklahoma. Repeatability estimates calculated from data adjusted for measurable environmental factors were found to be 0.37 ±.03 and 0.14 ±.03, respectively. On unadjusted data these estimates were 0.19 ±.03, 0.17 ±.03 and 0.11 ±.03, respectively. When the 70-day weights and gain from 70 days to 140 days were adjusted for birth weight as well as for sex, type of birth and year, the estimates for these two traits were 0.15 ±.03 and 0.11 ±.03, respectively. (AH b3-7)

B. Selection and System of Breeding

1. Breed comparisons and crossbreeding. The effect of crossbreeding on total production of the ewe was measured by indexes that consider both pounds of lamb weaned and pounds of wool sheared. The data include five purebred groups of sheep including Hampshire, Shropshire, Southdown, Merino and Targhee and one strain evolved from a Columbia-Southdale cross. The work also includes 9 groups of 2-breed cross lambs, 20 groups of 3-breed cross lambs, and 6 groups of 4-breed cross lambs. A total of 2369 lambs over a period of 11 years were included in the study. Three indexes were used. Index I was computed by adding weaning weight of the lamb adjusted for sex and age to the fleece weight multiplied by 2.5. Index II was computed by dividing Index I by the fall body weight of the ewe. Index III was the same as Index I except the lamb weights were not adjusted for sex and age. Production Index I ranked Targhees first (101.1) followed by Hampshires (73.4), Columbia-Southdale (68.9, Merino (62.3), Shropshire (54.7) and Southdown (43.6). When Index II was used the large ewes are penalized and the variation between breeds is reduced. For Index II the Targhees are first (73.0), followed by Merino (62.8), Columbia-Southdale (59.6), Hampshire (59.1), Shropshire (49.9) and Southdown (46.5). The Targhees and Columbia-Southdale ewes were not used in the crossbreeding work. However, when Hampshire, Shropshire and Merino ewes were mated to produce crossbred lambs the indexes were generally superior to purebred ewes producing purebred lambs. When production was measured with Index I and III, Hampshire ewes mated to either Shropshire or Southdown rams produced the highest indexes. When Index II was used, the Merino ewes mated to the mutton breed rams were most productive. For Index I the overall averages for all pure breeds, 2-breed crosses, 3-breed crosses and 4-breed crosses were 58.5, 65.6, 77.9 and 80.2, respectively. For Index II these averages were 54.6, 62.3, 68.3 and 67.4. (AH b1-1, 2, 3, 4)

2. New strains of sheep for lamb and wool production. Work has been started at Beltsville, Maryland, to develop a strain of sheep capable of lambing more than once each year. Such a strain would demonstrate the effectiveness of selection in changing reproductive frequency and removing the seasonal restrictions on reproduction. At present, ewes of this strain are bred to lamb three times in two years. A total of 216 ewes have lambed since 1961. These 216 ewes represent 8 complete reproductive cycles and 201 lambs have been weaned. Fertility is lowest from breeding in April and August and lamb mortality is highest in lambs born in September. Sires used in this strain are selected on the basis of their mothers' fertility and fecundity. (AH b1-17)

3. Comparisons of breeding systems. Preliminary results, based on weanling progeny from 60 Rambouillet sires randomly selected from the upper and lower halves of each breeding group and tested on an unrelated tester stock (8 test ewes per sire), show that test progeny from sires from the noninbred selected control group were superior in both weaning weight and overall merit to those of sires from the randomly bred stabilized control

group, recurrently selected inbred lines, all inbred lines and a few sires from commercial sources. The superiority of the selected control sires was due chiefly to the more open faces, less wrinkled necks, and slightly greater weaning weights of their progeny. The range in overall merit of progeny from the above breeding systems was 15 index points from the best to the poorest, and the range in weaning weights was 4 pounds. The breeding systems ranked, for overall merit, in the order listed above, but for weaning weight the recurrently selected inbred sires ranked last instead of third.

Evaluations of the breeding systems based upon offspring, produced entirely within the system rather than from a tester stock, revealed that the earlier established pattern of selected control superiority and inbred line inferiority continues to be repeated in all breeds at the Dubois station. However, in the Rambouillets, where line cross information is now available on all lines, the line cross progeny were superior to progeny from all other systems in weaning weight and superior to both inbred line and stabilized control progeny in overall merit. Again the superiority of the selected control in overall merit was due principally to less covered faces and less wrinkled necks of progeny from this group. All line cross and inbred line data were adjusted for the effects of inbreeding of the dams in making the above comparisons. These line cross results in the Rambouillets tend to support last year's line cross findings in Columbias and Targhees all of which tend to modify earlier line cross findings based on much less comprehensive data, which generally placed the line crosses in an intermediate position. (AH bl-5).

4. Testing of inbred lines. The testing of inbred lines has been continued with both topcross and line cross matings. For the 27 inbred Rambouillet lines, the topcross offspring were obtained by mating sires from each line to noninbred and unrelated test ewes. Weanling lamb indexes ranged from 134.5 to 145.5 for the top 9 lines with an average of 138.0 for all 27 lines. The top 9 lines from the line-crosses ranged from 146.6 to 157.1 with an average of 143.9 for all 27 lines. Weaning weights of top cross lambs ranged from 73.5 to 77.0 pounds compared to 75.8 to 79.2 for average of the line cross lambs. Only low correlations existed between the ranking of the lines in the test groups for overall merit and weaning weight. Results based upon the overall merit (index) of Targhee topcross progeny as yearlings showed the top third (7) lines to range from 133.3 to 136.0 with an average for all 21 lines of 130.6. Line cross progeny of the top 7 lines ranged from 141.7 to 146.8 with an average of 141.3 for all lines. The yearling progeny indexes for the top third (4) lines in the Columbia breed ranged from 227.9 to 243.2 with an average of 224.5 for all lines for the topcross matings. The top 4 lines in the line cross progeny ranged from 239.8 to 242.4 and averaged 237.4 for all lines. Several of the Targhee and Columbia lines were superior in both the topcross matings and the line cross matings, thus it appears that the superiority of a few lines may be emerging in these two breeds. (AH bl-5 and AH bl-14)

5. Selection for range sheep improvement. To investigate the rate of improvement of wool and lamb production in a commercial flock a cooperative study with the Redd Ranches, LaSal, Utah, and the Utah and Colorado Experiment Stations was begun in 1957 when about 1000 select ewes were chosen from some 15,000 as a select flock from which to raise replacement rams. Since the first lambs were weaned from this flock in 1958, about 1/2 of the ram lambs have been saved and at yearling age 10-15% are used with the select ewes. About 70% are used with the main ewe flock. Selection differentials have ranged from 10-12 lbs. for weaning wt., .09 to .14 inches for staple length and 0.12 to 0.24 for face covering score. At yearling age staple length in these rams has increased an average of .15 inches each year since 1960. Grease fleece weights have varied from 8.68 lbs. in 1960 to 11.30 lbs. in 1962. Body weights at yearling age have varied from 119 lbs. in 1960 to 140 lbs. in 1961. (AH b1-16)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

Harrington, R. B. and Whiteman, J. V. 1963. Estimates of the repeatability of lamb growth as a characteristic of the ewe. J. Anim. Sci. 22(3), p. 819 (abstract). (AH b3-7)

Marchello, J. A., Cramer, D. A. and Knapp, B. W. 1963. Composition of ovine fat. III. Effect of sire. J. Anim. Sci. 22(3), p. 828 (abstract). (AH b1-10, 11, 12)

Munson, A. W., Walter, L. E. and Whiteman, J. V. 1964. Relationship of some growth factors with carcass composition in milk fat wether lambs. Oklahoma Livestock Feeder's Day Progress Report, April 18, 1964, pp. 51-57. (AH b3-7)

Price, D. A., Ercanbrack, S. K., and Wilson, L. O. 1964. Relative accuracies of several methods of estimating clean fleece weight. J. Anim. Sci. 23(2), p. 350. (AH b1-6)

Wilson, L. O. Lamb Birthcoat. National Wool Grower 54:12. (AH b1-6)

Selection and Systems of Breeding

Ercanbrack, S. K., Blackmore, D. W., Van Horn, J. L., Blackwell, R. L., Hoversland, A. S., Kyle, W. H., Drummond, J., Terrill, C. E., and Willson, F. S. 1963. Components of variation and covariation of weanling traits of topcross lambs. J. Anim. Sci. 22(3), p. 818 (abstract). (AH b1-14)

Sidwell, G. M., Everson, D. O. and Terrill, C. E. 1964. Lamb weights in some pure breeds and crosses. J. Anim. Sci. 22(3), p. 822 (abstract); 23(1), pp. 105-110. (AH b1-1, 2, 3, 4)

SHEEP AND GOATS - PHYSIOLOGY
Animal Husbandry Research Division, ARS

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season, and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with five State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 2.6 professional man-years. Of this number 0.8 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.3 to physiology of wool and fiber, and 0.4 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The current research program at the State experiment stations in the area of sheep physiology is concerned primarily with attempts to understand the endocrine shifts responsible for the seasonal breeding behavior of sheep and means of altering it. States in the southern region and the USDA are cooperating in regional project S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South, in a study of the various factors important in seasonal and non-seasona eproduction. Light, temperature and genetic constitution are receiving major emphasis. Other studies are concerned with determination of abnormalities in the ova which appear to render them incapable of implantation, and nutrition and management factors important in regular reproduction. The technique of ova transplantation has been successfully used in this research.

In an attempt to more accurately assess the effects of stresses of nutrient restriction, altitude and temperature on growth and productivity of range sheep, the States of the western region and the USDA are cooperating in regional project W-46, The Effects of Environmental Stresses on Beef Cattle and Sheep Production. The stations are comparing full feed and water with varying percentage restrictions along with the influence of altitude, physical nature of the diet, range supplementation, geographical location and temperature as these affect blood chemistry, body composition, wool quality, lamb production, and milk production during the nursing period.

The influence of growth rates of ewe lambs on subsequent production is being studied as is the effect of hormones and hormone-like substances, alone or in combination with antibiotics, on growth and fattening of lambs. A fundamental approach to gain an understanding of the physiology of growth involves a study of the effect of feeding specific metabolites such as sodium proprionate upon blood glucose levels and growth rates of lambs.

The total State scientific effort devoted to sheep and goat physiology research is 10.3 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Breeding capacity of range rams. The number of ewes with synchronized estrus periods which can be successfully mated to one ram was investigated. Ewes were checked for estrus and placed with the ram at 8-hour intervals. Most of the 59 to 62 ewes assigned to each ram were in heat within a 4-day period (equivalent to 250 ewes in normal mating.) Sixty-six percent of the synchronized ewes lambed from the first exposure which excelled fertility of control pens. Thus, the number of synchronized ewes which can be bred naturally is much higher than expected. (AH bl-7)

2. Synchronization of estrus with orally active progestin. A 2-year study showed good synchronization with all treatments with 85% of all ewes coming into heat within a 4-day period. Fertility was higher at the second post-treatment estrus (79%) than at the first (59%). Feeding progestin for 12 or 14 days had no significant effect on subsequent fertility but 60 mg. daily dosage gave better fertility than 50 mg. (74% vs. 64%, $P > .05$). (AH b1-7)

At Fort Reno, Oklahoma, estrus was effectively synchronized in 3 of 4 trials with non-lactating ewes. Lactating ewes did not mate immediately after feeding progestin but did show synchronized estrus periods about 3 weeks after end of feeding. Milk production was unaffected. Estrus was not well synchronized in late summer breeding of 10-month old ewe lambs when mated at second estrus after end of breeding. (AH b3-7)

3. Effects of variation in light on reproductive phenomena during the breeding season. Mature ewes were randomized (1961-63) within breed and age into 8 groups receiving normal light, continuous light, continuous darkness and combinations changing after 17 and 34 days, and intermittent light (2 hrs. on and off). Treatment began at about the first and ewes were mated at the third synchronized estrus. Corpora lutea and ova or embryo data were obtained at 3 and 31 days post breeding. Light treatment had a significant effect on ovulation rate ($P < .02$, range 1.73-2.17). Continuous dark and intermittent light had the highest rates. There were no significant differences in rate of ova recovery, fertilization, abnormal ova, abnormal embryos or normal embryos at 31 days (ave. 1.45/ewe) or in apparent loss of potential embryos. (AH b1-7)

4. Ovarian response to PMS in progesterone and estradiol treated ewes. Percent of ewes ovulating were control, 100; 8 mg. progesterone daily plus PMS, 80; 16 mg. progesterone daily plus estradiol plus PMS, 80; 1200 i.u. PMS on day 14, 78; 8 mg. progesterone daily, 20; 16 mg. progesterone daily plus PMS, 10; 16 mg. progesterone plus estradiol, 10; and 16 mg. progesterone daily, 0.

Average follicular fluid weights were significantly higher in groups receiving 8 and 16 mg. progesterone plus PMS and tended to be lower in groups receiving 16 mg. progesterone only or 16 mg. progesterone plus estradiol. Average uterine weight was significantly higher in the group receiving PMS only (91.3 gm.) and significantly lower in groups receiving 8 and 16 mg. progesterone only (53.4 and 44.1 gm.). The results indicate a gonadal-gonadotropic hormone interaction probably at the level of the ovaries. (AH b1-7)

5. Vaccination for enzootic virus abortion in sheep. Approximately 400 yearling and 400 2-year old ewes were vaccinated with a killed viral vaccine in the fall of 1960. More of the vaccinated ewes had live lambs and fewer had dead lambs than non-vaccinated ewes but the differences were not significant. However, the number of dry ewes including ewes with unobserved abortions, was significantly greater (158 of 833 ewe records) for non-vaccinated ewes than for the vaccinated ewes (20 of 669 ewe records) (AH b1-7)

6. Fetal electrocardiography in livestock. Extensive studies on fetal electrocardiography of cattle, sheep and goats at Beltsville, Maryland, show it to be a useful technique in detecting pregnancy and fetal well-being. Tracings can be obtained in five minutes or less with cattle. Fetal R waves can be detected by at least mid-term and with an accuracy of 100% during the last 3 months of gestation. The fetal heart rate tends to decline and the amplitude of the fetal R wave increases with fetal age. Pregnancy was detected in all 11 cases with dairy goats and as early as mid-term. A different technique is needed for sheep because of the electrical insulation properties of wool and high noise factors. Silver plated probes inserted subcutaneously offer promise. About 90% accuracy has been obtained in detecting pregnancy in ewes. Vaginal and rectal electrodes are being developed. (AH b3-12)

B. Environmental Physiology

1. Effect of geographic location on color of wool. Comparisons of color were made from individual fleece tops from comparable groups of Rambouillet rams kept in Maryland, Georgia, Idaho, and New Mexico over a four-year period. Rams kept outside showed slightly more color than rams kept indoors. Individual and yearly variations in color were found. In general, fleeces produced in the dry areas of Idaho and New Mexico were white or nearly white, while those produced in the more humid areas of Georgia and Maryland, tended to be yellowish in color. (AH b3-8)

C. Physiology of Wool and Fiber

1. Comparison of a normal and bare skin area in a lamb. Biopsies of normal and bare areas of skin of a 7-month old Columbia X Southdale lamb showed that the keratinized epidermis of the bare area was thicker than the epidermis of the wooled skin. The general blood supply of the bare skin appeared normal but it lacked the branches of arterioles and capillaries supplying wool follicles. Thus, it appears that additional branching of blood vessels in wooled skin is conditioned by the density and type of the follicular population. (AH b5-1)

2. Lipid content and incidence of cholesterol in sebaceous glands of sheep and goats. Tests for lipid content and incidence of cholesterol in sebaceous glands of Merino, Dorset, Shropshire, Morlam, and Navajo skin biopsies show that seasonal differences may exist for incidence of cholesterol but not for lipids for both rams and ewes. (AH b5-1)

3. Incidence of lecithin in the skin and follicles of sheep and goats. Lecithin could not be demonstrated in secreting sebaceous glands of postnatal sheep and goats but it was present in fetal glands. No traces of lecithin were found histochemically in or about growing wool, mohair, or hair follicles but it was invariably present in non-growing or shedding fibers of goats. (AH b5-1)

4. Observations on mohair follicles and lock types. Skin biopsies from 11 Angora goats in Texas and 9 in South Africa revealed that fibers from secondary follicles were generally not medullated except one with straight mohair locks. Medullated fibers were lowest with ringlet locks while intermediate for mixed or flat type locks. Medullated fibers, generally from central primary follicles, made up about 3.5% or less of the total fibers. (AH b5-5)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

Hulet, C. V., Foote, W. C., and Blackwell, R. L. 1964 Effects of natural and electrical ejaculation on predicting fertility in the ram J. Anim. Sci. 23(2): 418-424. (AH b1-7)

Hulet, C. V. and Foote, W. C. 1964. Effects of variation in light on reproductive phenomena in ewes during the breeding season. J. Anim. Sci. 23(3): p. 861 Abstract. (AH b1-7)

Foote, W. C. and Hulet, C. V. 1964. Ovarian response to PMS in progesterone and estradiol treated ewes. Proceedings Western Section Amer. Soc. Anim. Sci. 15: XVI-1 through 6. Also J. Anim. Sci. 23(2): 591. Abstract. (AH b1-7)

Physiology of Wool and Fiber

Margolena, L. A. 1963. Sebaceous glands of sheep and goats. The Virginia Journal of Science. Proc. vol. 14(4): 170. Abstract. (AH b5-1)

Margolena, L. A. 1963. Comparative study of a normal and a bare skin area in a Columbia X Southdale lamb. Zeitschr. mikr.-anat. Forschung, vol. 70, Heft 4, 478-483. (AH b5-1)

SHEEP AND GOATS - NUTRITION AND MANAGEMENT
Animal Husbandry Research Division, ARS

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Divisions of ARS, and in formal and informal cooperation with State Agricultural Experiment Stations of Delaware, Idaho, Maryland, Montana, Oklahoma, Texas, and Utah.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.2 to range and pasture management, 0.4 to management practices, equipment and facilities, and 0.4 to program leadership.

A grant involving Public Law 480 funds is in progress at the Ankara University, Ankara, Turkey, and is related to the methods of feeding and management on white muscle disease in lambs. The program is supported for 3 years (1963-1965) by $9333, equivalent in Turkish lire.

PROGRAM OF STATE EXPERIMENT STATIONS

Basic studies of the function of the rumen, including the function of rumen microorganisms and the metabolism of products produced by rumen microbial activity are being conducted. (Additional investigations of rumen function appear in area #1.) The effect of various mineral, hormonal, or antibiotic supplements upon ration digestibility and animal response are also under study.

Investigations are concerned with increasing the efficiency of sheep production through the use of concentrates at specific times in the growth of lambs (creep feeding), by formulating suitable rations for fattening lambs, and by devising economical rations for maintaining breeding ewes. The use of high-moisture corn and of the increased energy and protein available in the newly developed higher oil and higher protein corn are being studied.

Forage utilization studies include: (1) The influence of trace mineral supplementation. (2) The effect of grazing system upon forage quality and degree of utilization. (3) Forage digestion in the rumen.

The quantitative requirements for and the metabolism and interrelations of various minerals, proteins, and vitamins are being evaluated. The use of hormone, antibiotic, enzyme or other feed additives in improving growth and feed efficiency is a very active area of study. The relation of nutrition to animal disorders such as "stiff lamb disease," nitrate poisoning, and trace mineral deficiencies is receiving attention. The effect of prenatal nutrition upon prenatal and postnatal development of the young is also under study.

Management studies underway include: (1) Early weaning vs. conventional weaning. (2) Creep feeding. (3) Concentrate supplements for wintering ewes. (4) Gleaning corn fields with sheep. (5) The production efficiency of different weights of feeder lambs and of wether sheep for wool and mutton production. (6) Management effects upon rangeland and grazing animals. (7) Scales for chute sorting. (8) Self feeders.

The State Stations have 14.3 professional man years devoted to this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Metabolic disorders. A commercial ground limestone (carbotex), ground oyster shell, and a commercial defluorinated dicalcium phosphate (polyphos) were added to a known calculogenic basal diet of ground sorghum grain (40), cottonseed hulls (40), cottonseed meal (10), and molasses (10) to study their effectiveness in controlling urinary calculi in lambs. Daily feed consumption and average daily gains were 4.6 and 0.45 lb., 4.3 and 0.45, 4.0 and 0.35, and 3.4 and 0.33, respectively. The proportion of animals affected (stones in bladder or clinical cases) was 25, 15, 50, and 65%, respectively.

Ammonium chloride was effective in controlling urinary calculi in a 3-year study involving 91 steers and 220 lambs. Wethers developed more clinical cases while steers had a higher incidence of stones in the bladder. Neither limestone nor disodium phosphate was an effective control measure with steers, while limestone reduced the incidence 50% in wethers and disodium phosphate doubled the incidence. (AH b2-1)

Studies have been conducted at Ankara, Turkey, on white muscle disease of lambs. Two hundred and thirty-four affected lambs were treated by injection with 1 ml. of 0.1% solution of sodium selenite and of these, 128 received a second injection 10 days later. Recovery rate of the affected lambs was 94% and generally a significant improvement was noted within 24 to 48 hours after the first injection. In 1963, 128 affected lambs were injected with 1 ml. of 0.1% solution of sodium selenite in combination with an oral dose of 2 grams of vitamin E. Recovery rate of these lambs was 99%. Treatment with vitamin E alone was not as effective as treatment with sodium selenite. Treatment of pregnant ewes by injection with an 0.1% solution of sodium selenite did not yield conclusive results in preventing white muscle disease in the lambs. Injection of 645 unaffected lambs, in affected flocks, with sodium selenite prevented the occurrence of white muscle disease. Sodium selenite injection did not increase the weight gain of lambs when applied either to pregnant ewes or to their lambs. (A22-AH2- Turkey)

2. Feeding practices and procedures. Mortality of sheep (15 per group) receiving alfalfa hay pellets ad libitum, limited amounts of alfalfa hay pellets, concentrates and chopped hay mixture ad libitum, and limited amounts of concentrate-chopped hay mixture is being studied over their lifetimes. Only one death was ascribed to the treatments in the first year. This occurred in the self-fed pellet group and liver and intestinal pathology were found.

A technique has been developed to study depraved appetites of sheep receiving limited amounts of pellets by measuring the amount of wood consumed. This was inversely correlated with level of feed. Symptoms were reversible and considerable individual variation occurred. Animals showing most depravity of appetite also consumed the most feed when received ad libitum. (AH b2-5)

Metabolic fecal nitrogen excretion of 0.576 and 0.601 grams N per 100 grams of dry matter consumed by sheep on roughage diets adequate in all known nutrients were very similar to those determined by other investigators on low N diets (0.4 to 0.6 g. N/100 g. d. m.) and appeared to be independent of diet digestibility. (AH b2-7)

The effects of physical form, quality of forage and concentrate supplementation were studied factorily on the ad libitum forage consumption by yearling ewes. Differences in forage quality were obtained by diluting alfalfa hay with straw, and cracked corn was used as the concentrate. Results of the first one-half of the experiment indicated that voluntary consumption of pelleted forages was consistently greater than for the same forage, unpelleted and the difference increased with decreasing forage quality. Voluntary intake of pelleted forage was little affected by forage quality. Addition of concentrate had little effect on consumption of pelleted forages but decreased consumption of ground forages by an amount equivalent to the dry matter consumed in form of concentrate. (AH b2-7)

Winter feeding trials on 540 ewes were conducted to find a more economical and time saving method of feeding pregnant ewes. Comparisons were made of 5.8 pounds of baled hay fed on ground, 4.7 pounds of alfalfa hay pellets (100%), and pellets at 95 and 90% of NRC recommendations. Method of feeding and level of feed intake had no effect on body weight gains of ewes during feeding or on birth weights of lambs. Percent and pounds of lambs weaned of ewes lambing were 127 and 98, 123 and 97, 130 and 101, and 128 and 101, respectively. Grease fleece weights were slightly higher for ewes fed pellets vs. baled hay but level of pellet feeding had no effect.

Feeding ewes after lambing for about 25 days before being turned to grass or baled alfalfa hay or self fed on ground alfalfa hay pellets had no effect on pounds of lamb weaned per ewe lambing. In another experiment, lactating ewes self-fed pellets consumed 9.4 lb. and produced lambs gaining 0.4 lb. more in 20 days than ewes hand-fed 6 lb. of pellets per head per day. In another experiment, after lambing, 144 ewes with 170 suckling lambs were fed alfalfa hay, plus 1 lb. of oats; self-fed pellets containing 12.5% oats; alfalfa hay, no grain; and alfalfa pellets, no grain. Average body weights of the lambs at about 30 days of age were 26, 28, 24, and 25 pounds, respectively, showing a slight advantage for pelleting and supplementing with grain.

Ewe lambs which were fed baled alfalfa hay (4.5 lb.) on the ground are being compared with lambs fed 3.4 lb. of alfalfa pellets and lambs receiving pellets ad libitum in self-feeders during their first winter. Average body weights of lambs after winter feeding were 101, 116 and 143 lb. and yearling grease fleece weights were 9.5, 10.3 and 11.2 lb., respectively. Group differences narrowed to 6 and 0.8 and 7 and 0.6 lb., respectively, at 2 and 3 years of age. Lamb production was slightly greater for the self-fed ewes as 2-year olds. Lamb production per ewe as 3-year olds was 93, 92, and 91 lbs., respectively. (AH b3-9)

3. Studies on nutritive requirements of sheep. Over a period of 90 days from mid-April to mid-July the maintenance requirement of 15-month old crossbred wethers was 50 gm. of dry matter (alfalfa hay pellets) per day, per unit of metabolic size (kg. body weight 0.75). (AH b2-7)

Ewes fed 4.5 lb. ground alfalfa hay pellets the last 6 weeks of gestation, according to NRC recommendations, were compared with groups fed at 95, 90 and 85% of recommendations, respectively. Level of intake had some influence on body weight gains during feeding but only a small effect on birth weight. (AH b3-9)

B. Forage Evaluation and Utilization

1. Forage evaluation. Crown vetch in early bloom was cut and frozen and later fed to 10-month old wethers for 26 days. Average energy digestibility was 61% and voluntary consumption was 66 gm. of dry matter, per day, per kg. body weight 0.75. Average refusal was 8.6% of dry matter offered. These values are similar to published values for alfalfa, birdsfoot trefoil, and red clover harvested in early bloom. (AH b2-7)

2. Forage intake by range sheep. Digestion trials were conducted on a tall forb-type high mountain summer range at early, intermediate, and late stages of maturity. Forage was sampled by pre-fasted esophageal fistulated sheep. Crude protein and ether extract in the sheep's diet decreased with forage maturity from 17.0 to 14.1% and 3.7 to 3.3%, respectively. Nitrogen free extract content of the forage increased from 18.3 to 19.4% and lignin content from 9.4 to 11.5%. Gross energy content of the diet decreased from 1953 to 1943 kcal. A significant difference due to stage of maturity was found for all chemical components of the diet except crude fiber. Significant differences due to animal samples were found for crude protein ether extract, and crude fiber. A significant animal by period interaction was found for crude fiber. Dry matter digestibility decreased as the summer progressed. (AH b3-9)

C. Range and Pasture Management

1. Grazing practices. In grazing sheep and cattle together stocking rate, or cattle-sheep ratios, had little, if any, effect on animal gain. Overall average daily gain for sheep was 0.33 lb. There were no significant differences in forage consumption or digestibility between animal treatments and stocking rates. Differences between sheep treated alike were very large. Gains of harnessed bagged sheep were considerably less during sampling period than for untreated lambs. Neither cattle nor sheep hematocrits or sheep fecal egg counts were affected by animal treatments. Thus it appears that differences in animal gains were not related to an interaction between livestock species in helminth parasite relationships. (AH b3-10)

2. Management in relation to parasitism. Two groups of lambs were weaned at about 60 days of age and grazed on relatively clean and on light to moderately contaminated pastures. Lambs grazing with their mothers on contaminated pastures until weaning at 120 days and on the same pastures after weaning were treated by drenching with phenothiazine, with access to a 1:9 phenothiazine mineral mixture or only as mineral mixture, and by drenching with thiabendazole, with access to a 1:49 thiabendazole-mineral mixture or to only a mineral mixture. Parasitism in the first two groups were nil on July 1. Fecal egg counts in the other groups were 996, 1825, 2211, and 1630 haemonchus eggs per gm. and 142, 31, 147, and 85 strongyloides eggs per gm., respectively. No significant differences in average body weight of the lambs were found on July 1. (AH b3-11)

D. Management Practices, Equipment and Facilities

1. Continuous vs. night breeding in producing fall born lambs. No difference was found in percent of ewes lambing but ewes mated at night lambed two days earlier and had more twins than ewes mated continuously. (AH b3-7)

2. Time of parturition in ewes. Data over a 5-year period on 1,270 ewes showed significant period effects for time of parturition where ewes of all ages and types of birth were pooled. Peaks occurred between 9 and 12 a.m. and 3 and 6 p.m. Period effects were due to the parturition pattern of ewes 3 years and older and were largely a result of variations in frequency of multiple births of these ewes. (AH b3-6)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

Lindahl, Ivan L. and Terrill, C. E., 1963 Use of pelleted roughage in the feeding regime for breeding sheep. J Anim. Sci. 22, 953-955. (AH b2-5)

Price, D. A., Humphrey, R. D., and Frederiksen, K. R. 1963. Response of ewe lambs to hay quality and feeding method. J. Anim. Sci. 22: 844 (Abstract) (AH b3-9)

Forage Evaluation and Utilization

Reynolds, P. J., Jackson, Charlie, Jr., Lindahl, I. L., and Henson, P. R. 1964. Consumption and digestibility of crownvetch by sheep. Paper presented at Crownvetch Symposium, University Park, Penna., July 8 and 9, 1964. Abstract to be published in proceedings of Symposium. (AH b2-7)

Range and Pasture Management

Price, D. A., Lindahl, I. L., Frederiksen, K. R., Reynolds, P. J. and Cain, C. M. Jr., 1964. Nutritive quality of sheep's diet on tall forb range. J. Anim. Sci. 23: 603 (Abstract). (AH b3-9)

Management Practices, Equipment and Facilities

Lindahl, Ivan L. 1964. Time of parturition in ewes. Animal Behaviour 12: 231. (AH b3-6)

PRODUCTION INFLUENCES ON LAMB AND WOOL
Animal Husbandry Research Division, ARS

Problem. Beef, lamb, pork, and poultry are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality, as well as in plentiful supply, if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, tenderness, full flavor, and color desired by the consumer are the goals the meat producer must strive to attain through breeding, feeding, and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Egg shell strength and yolk quality, strength of wool, fatness, quantity, flavor, color, and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood, even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb, and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was continued on a reduced scale, primarily to bring to a conclusion some phases of electrical immobilization and physiological responses. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the Human Nutrition Research Division, the Agricultural Engineering Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 15.6 professional man-years. Of this number 5.5 are devoted to beef; 1.1 to lamb, mutton, and chevon; 4.0 to pork; 1.0 to poultry and eggs; 2.1 to wool, fur, and fiber; 0.5 to humane slaughter; and 1.4 to program leadership.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding, and management. Its duration is for five years (1960-1964) and involves PL 480 funds with $42,784 equivalent in Polish zlotys.

PROGRAM OF STATE EXPERIMENT STATIONS

Lamb, Mutton, and Chevon. A limited amount of research is concerned directly with the influence of nutrition and management on quality of lamb produced, but a concerted effort is being made in the western region under W-61 to define and measure carcass quality and to determine the effectiveness of selection for muscular development. Several stations are studying the pattern of growth in different breeds and crosses as affected by feed, sex, and type of birth.

The total State scientific effort devoted to production influences on animal products research is 51.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Lamb

1. Tenderness and palatability. Data obtained on 49 lamb legs that were tested for palatability and objective tenderness showed pronounced variability in tenderness, particularly the Warner-Bratzler shear values. These values ranged from 8.0 pounds to 36.2 pounds and had a standard deviation of ± 5.97 pounds. The wide range of values in palatability scores for tenderness, juiciness, and overall desirability resulted in large standard deviations and coefficients of variability; the latter were 21.2%, 23.3%, and 28.1%, respectively. The Warner-Bratzler shear values had a coefficient of variability of 29.3%. (AH b6-1)

A statistical analysis of the palatability data from lambs used in a four-way crossing experiment over a period of 12 years and involving 724 lambs was completed. The results show a distinct trend in tenderness and flavor

of lean due to crossbreeding. Also, with an increase in desirability of fat flavor, there was an increase in desirability of flavor of lean. The results show that crossbreeding may be used to increase the palatability characteristics of lambs when Southdown, Shropshire, Hampshire, and Merino foundation stocks are used. (AH b6-1)

2. Composition. The fat and lean depth at the last rib was ultrasonically measured on 148 lambs during the two-year period. Comparison of these data with actual tissue thicknesses obtained from the carcass was accomplished using a correlation matrix analysis. Ultrasonic values made one inch off the midline correlated 0.55 with actual depth, loin-eye thickness, and covering fat. However, a similar correlation made for values obtained two inches off the midline was only 0.41. The latter value, although significant, suggests that more reliable estimates of tissue quantity are obtainable closer to the animal's midline. Among these lambs, the ultrasonic measurement made one inch off the midline of the live animal accounted for 66% of the total variation in the longissimus dorsi thickness as measured in the carcass. The two ultrasonic measurements accounted for 86% of the total variation in the longissimus dorsi thickness.
(AH d6-1 and MQ 3-34)

3. Carcass evaluation. Statistical analysis of lamb carcass data from over 1100 lambs used in crossbreeding studies showed that differences in year of birth were significant for all factors studied; ewe lambs were characteristically fatter than ram lambs, and there were definite advantages in both quantity and quality of lambs due to crossbreeding. A composite evaluation of crossbreeding effects indicated significant changes due to crossbreeding for all of the factors studied singly. A study of the interrelationships of selected factors indicated that most of the quantity factors were independent of quality factors among the crosses studied. This indicated that a sound crossbreeding program could be developed to improve both quantity and quality attributes in lambs without incurring any detrimental correlated responses. Carcass weight, average body width, plumpness of leg index, and fat thickness over the longissimus dorsi were the most useful carcass factors studied to predict quantity factors. The Warner-Bratzler shear and intensity of flavor of lean of roasted leg were the most useful factors to predict quality factors. (AH b6-1)

4. Breeding as it affects carcass quality. Publication of results from the Western Regional Project W-61 study which included data from the U. S. Sheep Experiment Station provided additional information on gross hereditary differences involved in lamb traits as determined by intra-environment breed differences. Twelve percent of the variance in live weight and carcass weight was attributed to breed effects. Live conformation

score, condition score, Federal grade and carcass conformation score showed rather large breed effects which amounted to from 32 to 47% of the intra-environmental variation. Breed differences accounted for approximately 25% of the variation in body length, heart girth, width of chest and depth of chest, and about 12% of the variation in most wholesale cuts, but essentially none of the variation in weight of loin or fat thickness at 12th rib. In general, breeds differed but little in the percent of the various wholesale cuts in the carcass. The intra-breed and environment correlation between Federal grade and live conformation and condition scores was on the order of 0.5. Between Federal grade and slaughter weight the correlation was 0.4. The value of the body measurements, body length and heart girth, for example, in predicting carcass merit, as measured by area of loin eye or combined weight of rack, loin and leg, were of no value when either slaughter or carcass weight was known and held constant. Similarly, live conformation score was of little value in predicting the two carcass measurements indicated. For lambs producing carcasses of the same weight, the ones with shorter bodies and the higher live conformation scores had greater thickness of fat over the 12th rib. Carcass weight accounted for the greatest variation in fat thickness, however. Neither live conformation nor condition score was effective in predicting area of eye muscle or weight of rack, loin and leg when live weight was held constant, nor were they very important when weight was free to vary. Both conformation and condition score appeared to be of some predictive value in estimating fat thickness at the 12th rib in weight constant lambs, with condition score being slightly more important. (AH b6-3C)

5. Factors affecting carcass merit in fed lambs. A study was conducted to determine the effects of various measures of fat content of lamb carcasses on carcass measurements and measures of retail merit of lamb carcasses. It was found that 3-year-old ewes produced lambs with more pounds of high priced cuts, more pounds of retail trimmed meat, and with smaller kidney knob than the other age of dam groups. There was a difference between years in carcass fat content. Also, a ration composed of 70% alfalfa, 20% milo, and 10% molasses resulted in carcasses containing more fat than a pelleted ration of 100% alfalfa. Ram lambs had less trimmable fat than wethers. Single lambs had the smallest loin eye area and twin ram lambs raised with ewe lambs had the largest loin eye area. There was a small breed difference in tenderness and lambs from 2-year-old dams were more tender than lambs from older dams. Four measures of retail merit used were: retail trimmed meat per day of age; retail value per hundred weight of carcass; pounds of retail trimmed meat and pounds of high priced cuts. Highly significant correlations were found among these four measures, and in most instances they were negatively related to the various measures of fat in the carcass. The correlations between these four measures of retail merit and pounds of fat trim were -.63, -.62, -.69, and -.56, respectively. Fat thickness over the loin was related to these measures of merit with correlations of -.33, -.35, -.32, and -.36, respectively.
(AH b1-10, AH b1-11, and AH b1-12)

B. Wool and Fiber

1. Factors affecting quality and value of wool. Investigation of the relationship between quality traits and the economic relations was continued in 1963. Staple length and fiber diameter were determined from measurements of 100 hook staples drawn from each grade lot. Clean fiber and vegetable matter content were determined by the core test. The 64/70's staple fleeces, made up approximately 91.3% of the fine wools, were 1.4 pounds heavier, and had 2.0% higher clean yield than the 64/70's French Combing fleeces. Average staple length of the 64/70's staple fleeces was 0.7 inches longer and the average fiber diameter was 0.4 microns coarser than the 64/70's fleeces classed as French Combing wool. The 64/70's staple wool sold for 62.5 cents a grease pound compared to 56.0 cents for the 64/70's French Combing wool. One lot each of 60.62's and 56/58's staple quality fleeces was studied. The 60/62's staple lot had an average fiber diameter of 23.7 microns, average staple length of 3.3 inches, clean fiber content of 48.47% and sold for 61.5 cents per grease pound. The 56/58's staple lot had an average fiber diameter of 26.4 microns, average staple length of 3.6 inches, clean fiber content of 51.04% and sold for 62.2 cents per grease pound.

The fleeces classed as 54/50's made up a lot of 4,165 pounds which had an average fiber diameter of 29.1 microns, average staple length of 3.8 inches, clean fiber content of 53.84%, and was used for special study of quality traits and mill tests of scourability of branding fluid. Commercial sorting of the 50/54's lot showed a main sort of 98.3% with only 0.7% of a lower grade than 50's. No paint sort was removed. Very little color remained in the scoured wool which did not affect or show up in the top. A top yield of 44.74% was much higher than average yield from territory 50/54's wools. The 46/48's fleeces made up a lot too small to be useful for price comparisons. Crutching and shearing pieces, which made up approximately 0.6 pound per fleece, were scoured with a clean yield of 40.3% and were sold as clean wool for $1.10 per clean pound. (AH b5-2)

2. Measuring methods to evaluate wool. Investigations on methods of measuring crimp in grease wool staples as an indication of the degree of crimp in a fleece are being continued. A method is in process of being tested, using two rulers at right angles to one another, with one stationary and the other movable. This method gives a more direct reading than does the triangular scale devised in the Beltsville laboratory. Analyses of results have not been completed. However, a method based on the use of the triangular scale is being written for submission as a tentative standard for the American Society for Testing Materials.

Work is progressing at Beltsville, Maryland, on the use of the Digital Fibrograph for measuring length of wool from top. Additional data have been obtained using clamps instead of combs in sample preparation. Results show that either method is satisfactory. The sample is more quickly prepared using the clamps.

The Electronic Fiber Fineness Indicator (EFFI) designed to measure fiber diameter and variability is being tested and evaluated under contract. Revisions have been made in the original circuitry. New developments indicate that further revisions would increase the value of the instrument in measuring more accurately. Study on the techniques of preparing samples for measurement are also being carried out. (AH b5-3C)

3. Relation of fleece traits to processing characteristics. Fourteen grade-breed lots of wool from Dubois, Idaho, each containing 15 mature ewe fleeces visually grading the same spinning count, were studied to investigate further relationships among quality traits of grease wool to processing characteristics, yield and quality of top. Each grade-breed lot was sampled in the grease, scoured at the University of Wyoming Wool Laboratory, and processed into top at Philadelphia College of Textiles and Science. Three years data show that as the fiber diameter of grease wool increases within a breed; staple length, grease fleece weight, and percent clean yield increase; and the number of crimps per inch decreases. Fiber length of the top from each grade-breed lot was approximately 0.11 inch shorter and the average fiber diameter of the top was 0.55 micron coarser than the grease wool from which it was combed. Variability of both fiber length and diameter in the top increased as the grease wool became coarser. Targhee fleeces were heavier than Columbia fleeces of the same visual grade. Rambouillet fleeces were heavier than Targhee fleeces of the same visual grade. Columbia wool was longer, had fewer crimps per inch, and was coarser than Targhee wool of the same visual grade. Targhee wool was longer, had fewer crimps per inch, and was coarser than Rambouillet wool of the same visual grade. Targhee wool had a slightly higher card yield than Rambouillet or Columbia wool of the same visual grade. (AH b5-7)

F. Humane Slaughter

1. Beltsville, Maryland. The study of physiological stress inflicted upon the hog previous to and during slaughter procedures was completed. The treatments consisted of captive-bolt stunning, electrical stunning, and no preslaughter stunning. The results showed small non-significant decreases in serum protein and in the albumin:globulin ratio when the hogs were immobilized with electricity. A highly significant increase in serum heme concentration occurred in the captive bolt and electrically immobilized groups. Evidence seemed to indicate that the symptoms of physiological stress might be the result of intense extensor muscular spasms associated with preslaughter stunning.

A similar study of the preslaughter and slaughter stresses due to captive-bolt, electrical, and no preslaughter stunning was conducted on lambs. Results showed that the serum heme pigment content was not increased significantly by the preslaughter stunning of sheep. Both the captive-bolt

and electrical stunning methods produced a highly significant increase in plasma potassium values and there were small but non-significant decreases for total protein and albumin:globulin ratio in lambs immobilized previous to slaughter.

This project has been discontinued after a six-month extension. (AH j1-2)

2. University of Minnesota. Studies were continued on the complex problem of determining if an animal feels pain upon being immobilized by the use of electrical current. The results of this experiment are being evaluated. (AH j1-3)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Lamb

Alsmeyer, R. H., Johnson, E. K., Thornton, J. W., and Hiner, R. L. 1963. Relationships among ultrasonic values, live weight, and yields of lamb and beef. (Paper presented at the North Atlantic Section, Am. Soc. of An. Sci. meeting, Morgantown, W. Va., July 1963) (MQ 3-34)

Mandigo, Roger W. 1963. Factors affecting the retail value of lamb carcasses. M.S. Thesis, New Mexico State University. (AH b1-10, AH b1-11, AH b1-12)

Stanley, M. E., Galgan, M. W., Russell, T. S., Blackwell, R. L., and Orme, L. E. 1963. Variation and correlation of live and carcass traits of lamb. Washington Agri. Exp. Sta. Bull. 649. (AH b6-3C)

Wool and Fiber

Hourihan, M. E., Terrill, C. E., and Harvey, W. R. 1963. Scale for determining crimp of wool staples. J. Anim. Sci. 22(3):819. (Abs.) (AH b5-3)

Hourihan, M. E., Terrill, C. E., and Harvey, W. R. 1963. Use of Fibrograph to measure wool fiber length. J. Anim. Sci. 22(3):819-820. (Abs.) (AH b5-3)

Humane Slaughter

Kitchell, R. L. 1964. Methodological considerations for assessment of pain perception in animals. UFAW Symposium Report, pp. 243-261. (AH jl-3)

Lynch, G. P., Fulmine, F. J., and Hiner, R. L. 1964. Some indications of physiological stress in hogs subjected to various preslaughter treatments. J. Anim. Sci., 23(3):547-550. (AH jl-2)

Lynch, G. P., Fulmine, F. J., and Hiner, R. L. 1964. Some indications of physiological stress in lambs subjected to various preslaughter treatments. J. Anim. Sci., 23(3):661-664. (AH jl-2)

INFECTIOUS AND NON-INFECTIOUS DISEASES OF SHEEP AND GOATS
Animal Disease and Parasite Research Division, ARS

Problem. There are at least 18 infectious diseases of sheep and goats in the United States that cause an estimated annual loss of 15 million dollars. Non-infectious diseases are estimated to cause an additional 3 million dollar loss annually. The cause of some of these diseases is known; others have more than one causative agent contributing to produce the effects seen in field cases. Environmental, genetic, and unknown factors appear to play a part in some diseases. The natural reservoirs of the known infectious agents have not been fully determined. Fundamental information on methods of transmission and means of prevention are needed for many of these diseases. Vaccines and other immunizing products are available for some diseases of sheep but not for others. Some of these products might be improved. Prevention, control, or eradication of disease is necessary for economic and efficient sheep and goat raising. Due to lack of accurate, rapid diagnostic techniques, infectious diseases often get a substantial start in a band or flock before they are recognized, partly because they are easily confused with non-infectious diseases.

USDA and COOPERATIVE PROGRAM

The Department has a continuous long-term program involving biochemists, microbiologists, pathologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of infectious and non-infectious diseases of sheep and goats. Research is being conducted on the diseases at the following designated locations.

The Federal scientific effort devoted to research in this area totals 9.9 professional man-years. This effort is applied as follows:

Bluetongue, 4.0 at the Denver Animal Research Laboratory, Denver, Colorado.

Contagious Ecthyma, 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Foot Rot, 2.0 at the National Animal Disease Laboratory, Ames, Iowa

Vibriosis, 0.6 at the National Animal Disease Laboratory, Ames, Iowa, and under cooperative agreements with the Colorado, Montana, and Utah Agricultural Experiment Stations.

Scrapie, 0.2 at the Agricultural Research Council Field Station, Compton, Berkshire, England, and the Moredun Institute, Edinburgh, Scotland, through two grants of PL 480 funds, equivalent to $300,165. The work is coordinated through the European Mission for Research on Animal Diseases, Amsterdam, Holland.

Viral Ulcerative Dermatosis, 0.1 through a cooperative agreement with the Colorado Agricultural Experiment Station.

Paratuberculosis or Johne's Disease, 1.0 at the National Animal Disease Laboratory, Ames, Iowa.

PROGRAM OF STATE EXPERIMENT STATIONS

Considerable attention is being given to many of the diseases of sheep and goats in order to reduce the cost of production thereby encouraging consumption of meat, wool and by-products of the industry.

At the present time, several States in the West (Regional Research Project W-27, Vibriosis in Sheep) are cooperating to develop methods for the prevention and control of vibriosis, one of the major disease problems of the sheep producer. Information is being sought on how the disease is transmitted and on the source of infection. Preliminary reports indicate that preventive vaccines offer promise as an aid in the control and eventual eradication.

Considerable emphasis is being placed on the development of reliable tests that can be used to identify outbreaks of bluetongue and the detection of carrier animals. Vaccines for the prevention of bluetongue are being evaluated by workers at several stations. Vectors, in addition to those already known, are being sought in order to improve present control measures.

Many States are giving attention to the prevention and control of white muscle disease (myodegeneration) in sheep and the relationship of the condition to similar problems in other animals, including man.

The influence of nutrition on the physical and chemical properties of urine is being studied to determine the cause of urinary calculi. Methods for prevention and treatment are being evaluated.

Conditions known as epididymitis and ulcerative dermatosis have become economic problems in some areas and several States are devoting considerable effort to determine means of control.

Other sheep and goat diseases being investigated by workers in various States are pneumonia, listeriosis, foot rot, ovine virus abortion, encephomalacia, etc.

The total State scientific effort devoted to diseases of sheep and goats is 20.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Bluetongue

1. Bluetongue virus isolations were made at the Animal Disease Research Laboratory at Denver, Colorado, from sheep blood samples representing suspected bluetongue outbreaks in 12 bands of sheep from 7 States, and from cattle blood samples from 6 herds from 3 States.

2. Detection of bluetongue virus in infective cell culture utilizing fluorescent antibody and electron microscopy. Bluetongue virus has been visualized in lamb primary kidney cell cultures and in serially passed McCoy Synovial cell cultures. The infective cycle has been determined utilizing goat bluetongue antiserum specifically conjugated with fluorescent isothiocyanate. The first indication of bluetongue infection occurred at 20-30 hours after the cells were inoculated, the cycle was complete within 40-60 hours of inoculation. The first sign noted was around the periphery of the cell where a thin band of apple green fluorescence was noted. This specific fluorescence moved toward the nucleus becoming diffuse in the cytoplasm and became concentrated around the nucleus at approximately 30-40 hours after culture inoculation. The first stage occurred when the fluorescence moved away from the nucleus again toward the periphery. Shortly after this phase of the cycle the cells underwent lysis and fell off the glass substinate.

Cytoplasmic inclusion bodies were noted in the cultures as early as 25 hours, however, at this time there was none-to-weak fluorescence. After 30 hours incubation the inclusion bodies absorbed the specific conjugate with increasing brilliance until the cells underwent lysis. Cultures were studied 36 hours after inoculation with bluetongue virus utilizing the ultramicrotone. Mature and immature virus was noted in the areas associated with specific fluorescence. Electron microscopic studies of inclusion bodies showed virus particles within the structure. Virus measured directly on the photomicrograph was found to be elliptical and 100 x 80 millimicrons in size. The virus consists of a ribonucleic acid (RNA) core surrounded by a clear capsule.

3. The clinical and immunogenic response of sheep to oral and intradermal inoculation of bluetongue (BT) virus. All principal sheep became infected subsequent to intradermal inoculations of 1 ml. of a dilute (10-3) bluetongue virus 3 times per week for 26 weeks. The incubation period was prolonged. One contact control sheep developed bluetongue. Two of 7 sheep, on a like test, that received 1 ml. of dilute (10-5) bluetongue virus responded. One of the 2 sheep reacted to homologous challenge, whereas neither had significant serum neutralization indexes. Five of 7 sheep that received oral inoculations of 0.25 ml. of bluetongue virus blood in an anticoagulant preservative solution (OCG) 3 times per week for 26 weeks showed clinical reaction. Only one had a significant serum neutralization index and resisted homologous challenge.

4. The viremia of bluetongue infected sheep. Bluetongue virus was successfully titered, for the first time, directly from sheep blood in embryonating chicken eggs.

Four sheep were infected with BT-262 virus isolated during the first week of July, August, September, October, and December, for a total of 20 principal sheep. Two additional sheep served as non-infected temperature control sheep for each separate month's experiment. Blood samples were collected in OCG for 21 consecutive days from the principal sheep. The average peak BT virus activity, measured by the total number of BT virus chicken embryo mortalities, occurred on day-after-inoculation (DAI) 7. The bulk of the virus activity occurred on DAI 4 through 10 with the intermittent detectable virus present as early as DAI 1 and as late as DAI 21. The individual sheep virus titers, expressed as the log titer LD_{50} per 1 ml. blood in OCG, ranged from zero to 4.0. The zero titering blood had detectable virus present on DAI 6 through 10, and again on DAI 17. Blood virus collected in August gave the highest and most consistent titers. During 21 consecutive days of virus assay, the sheep with the best viremia had the highest virus titers.

5. Enhancement of sheep's response to oral doses of bluetongue virus. Forty eight sheep of similar age, weight, and sex were utilized to study the influence of orally administered bluetongue virus on the subsequent BT clinical response when the sheep was given an intradermal injection of the homologous virus. The sheep were divided into 5 separate groups. Group I had 14 principal and 8 virus control sheep. The principal sheep were given 2 ml. of blood virus in OCG daily for 5 days and then inoculated intradermally with the same virus on the day after oral administration (DAOA) 29. The virus control sheep were treated identically and representative of all control sheep with the exception that the oral inoculum was normal blood in OCG. Group IIA had 10 principal and 3 control sheep. In this group the oral inoculum was 4 ml. of blood virus in OCG daily for 10 days and the sheep were challenged on DAOA 15. Group IIB and Group IIC each contained 3 principal and 1 control sheep and they received the same oral inoculum as the Group IIA sheep. However, they were challenged on DAOA 22 and 29 respectively. Group III had 3 principal and 2 control sheep in which each of the principal sheep were given a single oral blood virus inoculum of 10, 20, or 30 ml. One virus control sheep was given a single oral inoculum of 10 ml. and the other 30 ml. of normal blood in OCG. These sheep were challenged on DAOA 11. The most optimal enhancement of the clinical response of the sheep occurred in the Group IIA sheep. The enhancement response was reflected by more severe and prolonged mouth lesions, a marked leukocytosis following a longer duration of the leukopenia, and a slight increase in the daily average body temperatures.

6. Thermostability. The thermostability of bluetongue virus at various storage conditions and temperatures of inactivation was studied at pH 7.0. The virus was markedly thermostable, withstanding 3 years storage at room temperature. Thermal inactivation curves suggested first-order kinetics,

with two components at 37, 46, and 56° C, but only one at -70°C. The two-component curves were most likely due to a phenotypically determined heterogeneity of the virus population with respect to thermostability. While inactivation at high temperatures (46 - 56°C) was associated with marked changes in enthalpy and entropy, compatible with protein inactivation, the thermodynamic data obtained at a lower temperature range (36 - 46°C) suggested ribonucleic acid inactivation. Approximate energy of activation values below and above 37°C were 7.5 and 50 kcal. $mole^{-1}$ respectively.

7. Effect of different "Contact Conditions" on the bluetongue virus-antibody reaction and on the validity of the "Percentage Law". The effect of various times and temperatures of virus-antibody contact (contact conditions) on the bluetongue virus-antibody reaction was studied. Linear regressions of neutralized virus on antibody titers were compared in three different *in vivo* neutralization tests. In all three tests antibody titers were highly dependent on the virus test dose used, that is, the slopes of the regression plots were flat. In the two *in ovo* neutralization tests slow virus multiplication probably caused the flat slopes.

In conventional neutralization tests with limited contact conditions, the "percentage law" was invalid at low virus doses. With more favorable contact conditions the range of virus doses over which the regressions were linear and significant was extended gradually. Thus, the "percentage law" became valid for all virus doses. The invalidity of the law at low virus doses in conventional tests was most likely due to the inability of weak virus-serum mixtures to react to equilibrium in such tests. Changes in contact conditions did not significantly affect the slopes of the neutralization plots when these plots were based only on data in agreement with the "percentage law".

No reversibility of the bluetongue virus-antibody reaction was demonstrable by dilution of reaction mixtures at neutral pH. Reaction mixtures were held at both conventional and extended contact conditions.

Antibody titers were increased up to a hundredfold when extended contact conditions were compared with conventional methods. (Denver, Colorado)
(ADP a3-5)

B. Vibriosis in Sheep

In work under a cooperative agreement with the Colorado State University at Fort Collins, a study was made to determine the duration of immunity against ovine vibriosis which began November 1963 by vaccinating a group of yearling ewes prior to breeding. Vaccination was accomplished by giving a single 5 cc. subcutaneous injection of formalin-killed *Vibrio fetus* serotype I and serotype V organisms, mineral oil adjuvant, bivalent bacterin. An additional group of unvaccinated yearling ewes were maintained as controls. Ewes were randomized into separate lots and pens. At increasing yearly

intervals since vaccination the immunity of vaccinated and unvaccinated controls will be challenged at 2, 3, 4, 5, and 6 years of age. Immunity of 2-year-old ewes was challenged during advanced gestation, April 1964, with the combined V. fetus type I and type V (1:1 ratio) culture challenge. Twenty-three ewes, unvaccinated immunity challenge controls for the combined V. fetus type I and V organisms, had 9 vibrionic abortions. A single abortion occurred in 23 ewes vaccinated with the combined serotype I and V organisms when their immunity was challenged with the combined I and V V. fetus serotypes. No abortions occurred in the unvaccinated, unchallenged ewes which served as negative controls. (Fort Collins, Colorado)

In cooperation with the Montana Veterinary Research Laboratory of the Montana Agricultural Experiment Station at Bozeman, work has continued on vibriosis. An outbreak of vibriosis due to an unusual serotype was observed in a flock of ewes at this laboratory which had been vaccinated for vibriosis.

Antigens have been made and immunization of rabbits started. Serums will be adsorbed with cells in attempts to obtain pure serums representing the various "H" antigen factors. The serums will then be used to study the antigenic patterns of isolants, particularly those of unusual serotypes. Some improvement has been made in procedures for isolating vibrios from ovine feces. V. fetus has been recovered from feces for up to 25 days after rumen inoculation. A Vibrio which resembles V. fetus has been recovered from bovine feces. Two cultures of V. fetus, isolated from placentas during normal lambing of a farm flock in 1963, proved to be pathogenic for pregnant ewes when administered by rumen injection. It appears that the infection can be maintained from one season to the next in a flock although the lambing performance is normal. It is possible that the infection is maintained in carriers. (Bozeman, Montana)

In cooperation with the Agricultural Experiment Station at Logan, Utah, the replacement yearling ewes of 2 herds with a total of about 2,000 ewes each, were vaccinated for the 4th year with Vib-vac (Baldwin Laboratories, Omaha, Nebraska). No V. fetus organisms could be isolated from 48 abortions of the first and from 25 abortions of the second herd.

The duration of immunity of ewes vaccinated ½, 1½, 2½, and 3½ years ago was determined. Infection of the placenta, or the fetus, or both, with V. fetus was taken as failure. No V. fetus organisms were isolated from 15 ewes serving as normal controls, 15 of 16 ewes had infected uterine contents in the infected control group, while the rate of uterine infection was 8/16 ½-year after vaccination, 3/16 in the 1½-year group, 2/16 in the 2½-year group, and 4/16 in the 3½-year group. The u test proved highly significant protection in all 4 vaccinated groups.

Studies on the dynamics of the V. fetus infection were continued. The pooled logarithmic rate of clearance for a coccoid V. fetus strain was found to be -0.0128 which was significantly different from 3 other V. fetus strains with typical, comma-shaped cellular morphology. One of the latter was a V. bubulus strain being cleared from the ewes blood at a rate of -0.090, which did not differ from the clearance rate -0.0974 of a V. fetus strain of bovine origin. The clearance rate of 0.0576 of a typical ovine V. fetus strain, however, differed significantly from the latter 2 strains. The coccoid V. fetus strain, which remained for a long period in the blood stream, was lethal to all intravenously exposed ewes 5½ to 12 hours after inoculation. The animals developed a shock-like syndrome and died.

(Logan, Utah) (ADP a3-1(Rev.)

C. Scrapie

Investigations of scrapie in sheep and goats at the Agricultural Research Council Field Station, Compton, Berkshire, England, and at the Moredun Institute, Edinburgh, Scotland, have continued under the terms of the agreement.

Scrapie was first diagnosed in the United States several years ago. It is, however, not considered to be firmly established and efforts are continuing to eradicate it. Research has been conducted on this disease in Scotland and Great Britain for several years. The U. S. Department of Agriculture is supporting this research through PL 480 grants. In recent years, it has been determined that the disease is probably caused by a transmissible agent. The agent has, however, not been isolated nor characterized in detail. There is also increasing evidence that a certain genetic constitution is existent which determines susceptibility. Additional information is required about the disease before eradication procedures may be improved. Significant progress has been made in that the disease has been transmitted to mice and in this species the incubation period is 4 months, contrasting to the incubation period in sheep of 4 to 36 months. The disease is being transmitted serially in mice and efforts are continuing to adapt the transmissible agent to other species of animals. Efforts are also being made to isolate the transmissible agent and adapt it to tissue cultures. One of the things most needed and required before significant progress may be made on scrapie research is a rapid assay technique. Adapting the transmissible agent to tissue cultures appears to offer the most promise. A good biochemical approach is also being made to isolate the causative agent of scrapie from tissues from affected sheep, goats, and mice. In addition to the biochemical work under way, physicists are studying tissues from diseased animals using electronmicroscopy techniques in an effort to pin point the specific areas where the tissues are affected. The interest in research on scrapie has increased in the past two years and it is quite likely that due to this increased interest, significant progress will be made in developing a better understanding of the disease. (ADP a3-3)

D. Viral Ulcerative Dermatosis

In cooperation with the Colorado Agricultural Experiment Station, the disease was encountered in ewes and rams in the field. Materials collected were used to reproduce the disease in experimental sheep, and from these experimental sheep a secondary transmission was made. Pooled exudates from these were sent to the Wyoming University for virus propagation in tissue culture. A cytopathogenic agent was isolated. (Fort Collins, Colorado) (ADP a3-4)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Vibriosis

Miller, V. A., Jensen, Rue, and Ogg, J. E. 1964. Immunization of Sheep Against Ovine Vibriosis with Bacterins Containing Serotype I and Serotype V in Mineral Oil. Amer. J. Vet. Res., 25:664-667 May

Miner, Merthyr L., and Thorne, Joseph L. 1964. Studies on the Indirect Transmission of Vibrio fetus Infection in Sheep. Amer. J. Vet. Res., 25: 105:474-477.

Bluetongue

Bowne, J. G., Luedke, A. J., Jochim, M. M., and Foster, N. M. 1964. Current Status of Bluetongue in Sheep. Amer. J. Vet. Med. 144:7:759-764.

Bowne, J. G., Jochim, M. M., and Luedke, A. J. 1964. A Technique for Collecting Large Amounts of Sterile Blood from Various Animals. Amer. J. Vet. Res., 25:107:561-562.

Bowne, J. G., and Jochim, M. M. 1964. Technique for Handling Cover Slips Used in Cell Culture Systems. Canad. J. Comp. Med. & Vet. Sci., 28:4.

Scrapie

Dickinson, A. G., MacKay, J. M. K., and Zlotnik, I. 1964. Transmission by Contact of Scrapie in Mice. Jour. Comp. Path. and Thera., 74:3:250-254.

FOOT-AND-MOUTH AND OTHER EXOTIC DISEASES OF SHEEP
Animal Disease and Parasite Research Division, ARS

Problem. For the early detection of any outbreak of foot-and-mouth disease, comprehensive information regarding its effect on all susceptible species is necessary. The effect of foot-and-mouth disease (FMD) on cattle and swine has been, and is being investigated, however, little information is available pertaining to the disease in sheep. Sheep infected with FMD could serve as a source of infection and initiate the spread of the disease. Although primary research emphasis on exotic diseases of sheep at the Plum Island Animal Disease Laboratory is on FMD because of its great economic importance, other exotic diseases of sheep, such as rinderpest, sheep pox, louping ill, Nairobi sheep disease, and Rift Valley fever, are of concern to the Plum Island Laboratory because techniques and materials may be needed for diagnosis, control, and eradication on short notice and unexpectedly. Such diseases, if introduced into this country, could result in high death tolls or cause serious economic losses among susceptible sheep and other livestock. The problem is one of development of basic information applicable to protection of the nation's sheep from foreign animal diseases; development and maintenance of competence in diagnosis of these diseases, and fundamental research on the biological, chemical, and physical properties of the infectious agents that may be useful in prevention, control, and eradication of these diseases.

USDA AND COOPERATIVE PROGRAM

The Department has recently activated a continuing and long-term program involving veterinarians, biochemists, microbiologists, and pathologists, engaged in basic and applied research in some of the problems in this area.

The Federal scientific effort devoted to research in this area totals 2 professional man-years. This effort is divided among sub-headings as follows:

Foot-and-Mouth Disease of Sheep, 1.0 at the Plum Island Animal Disease Laboratory, Greenport, Long Island, New York.

Rinderpest in Sheep, 1.0 at the Plum Island Animal Disease Laboratory, Greenport, Long Island, New York.

Sheep Pox, Public Law 480 funds have been made available to the Turkish Ministry of Agriculture for a 2-year study of vaccines against sheep pox prepared from tissue culture propagated virus. The Madras Veterinary College, Madras, India, has also received PL 480 funds to conduct research on an efficient vaccine for protecting sheep against sheep pox. Sheep pox is indigenous in Turkey and India.

PROGRAM OF STATE EXPERIMENT STATIONS

None.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Foot-and-Mouth Disease in Sheep

Virus-neutralizing, complement-fixing and precipitating antibodies were detected in the serums of sheep following infection with foot-and-mouth disease virus (FMDV). Investigations have been conducted on the persistence of these antibodies. Virus-neutralizing antibodies were present 518 days postinoculation; precipitating antibodies 560 days postinoculation. Testing for complement-fixing antibody beyond 350 days has not been completed. The persistence of antibodies in sheep serums following infection with FMDV and the fact that neutralizing and precipitating antibodies may be readily detected is significant from a regulatory standpoint. (ADP all-1)

B. Rinderpest in Sheep

Sheep were experimentally infected with a bovine-lethal strain of rinderpest virus. The clinical response consisted of an elevated temperature during the third through the seventh day after inoculation and a reduced total white blood cell count beginning on the second, and persisting through the twelfth day after inoculation. Signs of illness were not obvious and gross lesions were not found. (ADP all-2)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Foot-and-Mouth Disease

Dellers, Robert W. and Hyde, John L. 1964. Response of Sheep to Experimental Infection with Foot-and-Mouth Disease Virus. Amer. Jour. Vet. Res. 25(105):469-473 :March .

Rinderpest

Barber, T. L. and Heuschele, W. P. 1963. Experimental Rinderpest in Sheep. Proc. 67th Ann. Meet. USLSA. 155-162

PARASITES AND PARASITIC DISEASES OF SHEEP AND GOATS
Animal Disease and Parasite Research Division, ARS

Problem. The cost of parasitic diseases to the sheep and goat industry of the United States is estimated to be in excess of $45 million annually. Disorders caused by parasites are ubiquitous, generally insidious and often overlooked entirely. Diagnosis is difficult, and successful treatments for many of these diseases are not available. Moreover, management practices to avoid spread of parasitisms and to control them are often ineffectual. The problem is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling or eradicating parasitic diseases so as to provide for healthy animals, insure adequate supplies of high quality lamb for an expanding population, avoid or minimize economic losses caused by these diseases, and thereby contribute to a prosperous agriculture, a sound national economy, a high standard of living, and a healthy population.

USDA AND COOPERATIVE PROGRAM

The Department has a continuous long-term program involving biochemists, parasitologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of parasites and parasitic diseases of sheep and goats. Research is being conducted on these diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 10.2 professional man-years. This effort is divided among sub-headings as follows:

Bionomics of Coccidial Parasites 2.0 at the Beltsville Parasitological Laboratory.

Effects of Helminth Infections on Serum Proteins 0.5 at the Beltsville Parasitological Laboratory.

Gastrointestinal Nematodes 2.1 at the Beltsville Parasitological Laboratory, and under a cooperative agreement with the Kentucky Agricultural Experiment Station at Lexington.

Helminth and Protozoan Parasitism in the South 1.5 at the Regional Animal Disease Research Laboratory, Auburn, Alabama, and through informal cooperation with the Mississippi Agricultural Experiment Station, State College.

Biology, Pathogenesis, and Control of Helminth Parasites of Sheep in the Southwest 2.0 at the University Park, New Mexico, field station, and through informal cooperation with the New Mexico Agricultural Experiment Station at University Park.

Effect of Intestinal Roundworms on Metabolism 0.1 under cooperative agreement with the North Dakota Agricultural Experiment Station, Fargo.

Control of the Common Sheep Scab Mite 2.0 at the Albuquerque, New Mexico, field Station.

PROGRAM OF STATE EXPERIMENT STATIONS

The majority of applied research in this area at the States involves sheep rather than goat parasites. Work is closely interrelated with parasite research in cattle and much of the basic work is applicable to cattle, sheep and goats.

Regional project W-35, previously mentioned under Area #11, serves to coordinate the work on sheep and goat parasites which is in progress in the Department and in the Western States. This group maintains informal cooperation with southern States working on this problem.

Information is being obtained concerning the effects on parasitism of climate, types of pasture grasses, stages of plant growth, rates of stocking, methods of supplemental feeding and early or late lambing. Several States are determining how the genetic background of sheep affects resistance or susceptibility to parasites. New anthelmintics and larvaecides are being evaluated to provide improved control measures.

Other studies are aimed at finding the source of infection and life cycle of the fringed tapeworm of sheep. Several States are evaluating chemical control and other procedures for reducing parasitic infection from liver flukes.

A number of States have basic work in progress on the physiological changes which occur in the host during parasitic infections. Other work is concerned with measurement by serological methods the immune response occurring in parasitized sheep. Radio-isotope techniques are being used to determine the effect which parasites have upon the absorption of essential food elements.

The States have 4.1 professional man-years of research involved in sheep and goat parasite research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Bionomics of Coccidial Parasites

At the Beltsville Parasitological Laboratory detailed studies on swollen mesenteric lymph nodes of sheep and goats infected with the coccidia Eimeria arloingi and E. ninaekohlyakimovi gave evidence that the schizont or early developmental stage of one or both of the parasites commonly occurs in the mesenteric lymph nodes and that edema fluid rather than the presence of the parasites is probably the primary cause of the enlargement of the nodes. (Beltsville, Maryland) (ADP b3-14)

B. Helminth and Protozoan Parasitism in the South

At the Regional Animal Disease Research Laboratory at Auburn, Alabama, pure cultures of oocysts of Eimeria intricata were obtained by micromanipulator isolation and feeding of small numbers to three lambs. These pure cultures were used in infection studies and in an attempt to determine the life cycle of this species which twice has been suggested as the one that produces the large (up to 700 μ) schizont-like bodies in the abomasa of sheep in various parts of the world.

The prepatent period in heavy, mixed, and pure infections ranged between 20 and 23 days, with a patent period of 6 to 11 days. In fresh smears, no endogenous stages were found at 8 days post-inoculation, but schizonts and merozoites were found 12, 15 and 18 days. The largest schizont measured only 52 x 58.5 μ but the largest merozoite was 3.9 x 20.8, giving a coarsely granular appearance to the mature schizonts. Gametocytes and immature oocysts were found in the lower small intestine. Nothing was found in the stomachs, cecum, or colon. Photomicrographs of the reported endogenous stages were made and sections are now being processed. (Auburn, Alabama) (ADP b3-19)

At the Auburn Regional Research Laboratory, oral inoculation of guinea pigs with 5,000 Trichostrongylus colubriformis infective larvae, followed by therapeutic termination of infection 2 days later, and intraperitoneal injection of 5,000 artificially exsheathed infective larvae, provided guinea pigs with protection against reinoculation. Single inoculations and injections were as effective as two inoculations or injections administered one week apart. (Auburn, Alabama) (ADP b3-21)

C. Biology, Pathogenesis, and Control of Helminth Parasites of Sheep in the Southwest

At the University Park, New Mexico, station, results from a preliminary experiment involving 18 lambs indicated that inoculation with an attenuated antelope strain of Haemonchus, a common stomach worm, followed 34 days later by treatment of phenothiazine, produced as effective a resistance to challeng with sheep strain Haemonchus as did inoculation not followed by treatment. It is postulated that drug treatment to remove immunizing infections after they have acted would be advantageous under practical conditions in order to prevent undue contamination of pastures.

Studies on the life history of Elaeophora schneideri, the arterial worm of sheep and deer, indicate that sheep are abnormal hosts and deer are normal hosts. Seven sheep, each having bloody lesions as a result of infection with this nematode, were examined for microfilariae of E. schneideri. Microfilariae could be demonstrated only intermittently in skin from the lesions of two animals. At postmortem examination of the five not showing microfilariae, only non-gravid females were found. Two mule deer and one white-tailed deer collected near Roosevelt, Arizona, were infected with E. schneideri. All had numerous microfilariae in the skin about the poll and face; none had any of the lesions so characteristic of infected sheep.

In investigations of the mode of transmission of the fringed tapeworm, a common parasite of western sheep, efforts were concentrated on insects known as bark lice, or psocids. These insects were collected on sheep range and fed to tapeworm-free lambs in an attempt to produce infections; the results were negative. Six species of psocids were cultured in the laboratory and exposed to tapeworm eggs; 169 tapeworm larvae were recovered from a total of 46 exposed psocids, but these failed to infect the four test lambs to which they were fed.

Of 53 sheep examined for liver flukes from southern Colorado and northern New Mexico, 15 were positive. Six species of snails from these areas were identified. Two of these species, Fossaria modicella and Stagnicola bulimoides techella have been incriminated as intermediate snail hosts in other areas.

The compound Bayer ME3625 was found to be effective in removing adult liver flukes from sheep when used at the rate of 300 or 450 mg/sheep but Neguvon at the rate of 100 mg/kg was ineffective. Absence of immature flukes prevented evaluation of the two drugs against these forms. Geigy compound GS 27384, was found to have some effect against the fringed tapeworm when used at a rate of 300 mg/kg, but this chemical was found to be quite toxic. Bayer 2353 removed 100 per cent of the tapeworms from 11 sheep treated at the rate of 600 mg/kg, while 10 untreated controls harbored an average of 27.9 tapeworms each. There were some mild signs of toxicity in treated animals, the importance of which remains to be evaluated.

New information is provided concerning parasites of mule and white-tailed deer in Arizona and New Mexico, bighorn sheep in Nevada, and javelina and jack rabbits in New Mexico. Trichostrongylus colubriformis, an extremely prevalent intestinal worm of sheep, was found in both javelina and jack rabbits, indicating that these animals may serve as reservoir hosts of this parasite. (University Park, New Mexico)(ADP b3-18)

D. Effect of Intestinal Roundworms on Metabolism

In cooperation with the North Dakota State Agricultural Experiment Station, Fargo, the effect of gastrointestinal nematodes on the tensile strength and sulfur content of wool was studied and the response of these factors to sulfur supplementation in the feed was also investigated. Four groups of eight lambs each were utilized. They were: 1) non-infected, non-supplemented; 2) non-infected, supplemented; 3) infected, non-supplemented; 4) infected, supplemented. All infected lambs were given 50,000 infective larvae of gastrointestinal nematodes, primarily Trichostrongylus sp. perorally by capsule. Supplemented lambs received sodium sulfate in the feed to provide 1 pound of sulfur per ton of feed. Infected lambs gained less weight during the trial period, but there was no apparent difference in tensile strength or sulfur content of the wool between the groups. The gastrointestinal nematodes were collected at the termination of the trial period and most of the infected lambs had heavy worm burdens.

There appeared to be no correlation between either worm load and sulfur content of wool, or worm load and tensile strength of wool. This was contrary to results of some earlier studies. There was an apparent depression of nematode infection with sulfur supplementation.
(North Dakota) (ADP b3-20)

E. Control of the Common Sheep Scab Mite

At the Albuquerque, New Mexico, field station, nine tests, involving groups of sheep heavily infested with Psoroptes ovis, numbering from 26 to 56 animals, were conducted on 4 candidate acaricides. All four products, in any concentration used, failed to eradicate infestations of the parasite. It was speculated that the reason for the failure of Co-Ral, cold lime-sulfur, Korlan and Ciodrin, three of which had previously proved successful in controlling sheep scab, was the temper and constitution of the test animal. The test subjects in this case consisted of highly pathogenic and resistant field strains of mites, including one designated "Corona", which was more vigorous, pathogenic and aggressive than any yet encountered at this laboratory.

Candidate and established acaricides were applied as a dip to 9 groups of uninfested sheep which were then challenged by being placed in a pasture with 40 sheep heavily infested with Psoroptes ovis. A group of 20 undipped, uninfested controls was also challenged in the same manner. The untreated sheep all became infested in from 13 to 34 days after challenge. The

dipped sheep were protected for periods ranging from 28 to 154 days. Most effective in its residual effectiveness was Toxaphene, followed by Ciodrin. Least effective was Delnav, Co-Ral, and a Korlan formulation.

Both single and double applications of unheated lime-sulphur dips, containing 1.75% calcium polysulfides, eliminated scabies infestations from heavily infested sheep. Success of treatment, however, was tempered by the fact that an avirulent strain of mites was involved in these trials. It was noted, following a subsequent test, that a single application of cold lime-sulphur dip at the above concentration of toxicant failed to eradicate an infestation of a highly pathogenic strain of P. ovis.

Observations were made at Albuquerque on the comparative pathogenicity of various strains of Psoroptes ovis. Recent experiences with a variety of strains have contributed much information to what has been suspected for several years regarding this subject. It has been shown that a) acaricides effective against avirulent strains of P. ovis may fail to control pathogenic strains; b) sheep harboring avirulent strains do not acquire resistance to virulent strains, c) pathogenic strains of mites appear to be highly refractory to chemical control, and d) avirulent strains are known to recede into a period of summer latency, during which time their existence is extremely difficult to establish, while pathogenic strains can be responsible for active acariasis well into or throughout the summer season. These observations have altered our concepts regarding the evaluation of acaricides for the control of scabies, and should contribute to the success of efforts to control scabies on a nationwide basis.

During investigations into the latency of Psoroptes ovis during the summer months, the questions as to where, and under what circumstances P. ovis oversummers, particularly in areas where summer atmospheric temperatures are high, appears to be nearing resolution. Continued studies into the oversummering locations revealed that a) mites apparently oversummer, in large measure, on the broad body surfaces of sheep, in locations where they displayed activity and produced skin injury during the previous spring, before entering into summer dormancy. Inspectors in search of evidence of scabies during the summer months are therefore advised to examine old, healing lesions as probable areas of involvement. b) there is no reason to suspect, at least in the Southwest, that mites are likely to escape direct contact with acaricides if dipped during the summer season, by virtue of their inaccessibility in "summer hiding places," such as the various cutaneous orifices. (Albuquerque, New Mexico) (ADP b3-22)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Bionomics of Coccidial Parasites

Lotze, J. C., Shalkop, W. T., Leek, R. G., and Behin, R. 1964. Coccidial schizonts in mesenteric lymph nodes of sheep and goats. J. Parasitol. 50(2):205-208

Helminth and Protozoan Parasitism in the South

Davis, Leonard R., Bowman, George W., and Smith, Willard N. 1963. Observations on the endogenous cycle of Eimeria ahsata Honess, 1942, in domestic sheep. Jour. Protozool., 10(Suppl.):18

Herlich, H. 1963. Observations on resistance to Trichostrongylus colubriformis in the guinea pig. Jour. Parasitol., 49(5 Sec.2):33-34

Isenstein, Robert S., and Porter, Dale A. 1964. Comparative size of infective larvae of Cooperia oncophora in feces of cattle and sheep. Jour. Parasit., 50:1:149-151

Biology, pathogenesis, and control of Helminth Parasites of Sheep in the Southwest

Allen, R. W., and Erling, H. G. 1964. Parasites of Bighorn Sheep and Mule Deer in Arizona with New Host Records. Jour. Parasitol. 50(Suppl):38

Hibler, C. P., Samson, K. S., and Allen, R. W. 1963. Dictyocaulus filaria in Colorado and New Mexico Sheep. Jour. Parasitol. 49:652

Hibler, C. P. 1964. Life History of Stephanofilaria stilesi Chitwood, 1934. Jour. Parasitol. 50(Suppl.):34

Samson, K. S., Allen, R. W., and Schad, G. A. 1964. Comparative Pathogenicity in Ovis aries of Homologous and Heterologous Strains of Haemonchus (Nematoda: Trichostrongylidae) from Domestic and Wild Sheep. J. Parasitol. 50:421-426

General

Guralp, Nevzat, Ozcan, Cahit, and Simms, B. T. 1964. Fasciola gigantica and Fascioliasis in Turkey. Amer. J. Vet. Res., 25:104:196-210.
(PL 480 Grant)

SHEEP AND GOAT INSECTS
Entomology Research Division, ARS

Problem. Sheep and goats are attacked by a variety of insects and ticks that are responsible for losses of many millions of dollars annually in reduced weight gains, decreased production and quality of wool, and in deaths of animals from gross attacks and insect-borne diseases. Sheep keds are a particularly serious pest in the northern States and screw-worms in the southwestern States. Fleeceworms, lice, and ticks are important pests wherever sheep and goats are raised. Safer, more effective, nonresidue-forming insecticides are needed to combat these pests. There is a special need to develop systemic insecticides that when given at low levels in feed, salt, or water would effectively control pests of sheep and goats and thereby save growers the expense of rounding up and treating flocks several times a year. New approaches to control, including attractants, chemosterilants, and radiation, should be explored and developed for controlling certain pests, as was done for the screw-worm in the Southeast. The possibilities of controlling insect pests of sheep and goats with insect pathogens, parasites, and predators also need to be investigated. Additional basic studies on the biology of the insects involved are essential for the development of biological and sanitation measures for their control. Research is urgently needed to determine which insects other than sand flies transmit bluetongue and the role of insects and ticks in the spread of other diseases of sheep and goats.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving basic and applied research on insects and ticks which affect the health and productivity of sheep and goats. Studies are conducted on the biology, physiology and nutrition of pests of sheep and goats, particularly the screw-worm and Culicoides gnats, with some attention to sheep keds and lice; on the nature of resistance to insecticides and on the length of time insecticides remain on animal skin and hair; and on the absorption, metabolism, degradation, excretion, and mechanism of action of insecticides on the insects. A program is underway to find new ways to control pests of sheep and goats, with special emphasis on chemosterilants, antimetabolites, attractants, and non-insecticidal materials. Efforts are being made to develop adult screw-worm attractants for determining the abundance of natural populations and for use in baits for control. Research is concerned with the development of more effective contact and systemic insecticides and with studies to devise sanitation or management procedures to minimize or prevent insect reproduction. Primary emphasis is given to the evaluation of new materials that leave small amounts of or no residues and to testing of formulations that will prolong effectiveness against insects and minimize toxicity hazards. Studies are conducted in cooperation with the Animal Disease and Parasite Research Division to determine the occurrence of residues in tissues of animals treated with insecticides. A limited program is being conducted on the

relationship of insects to diseases of sheep and goats, involving experimental transmission from diseased to healthy animals with various species of insects, and insect surveys in epidemic areas. Current studies are centered on the insect vectors of bluetongue disease of sheep in cooperation with the Animal Disease and Parasite Research Division. The research is conducted in major laboratories in Kerrville, Tex., and Corvallis, Oreg., and in satellite laboratories in Mission, Tex., and Denver, Colo. Investigations on the screw-worm were discontinued at Kerrville in September 1962 and moved to Mission, Tex., headquarters of the Southwest screw-worm eradication campaign. At the beginning of FY 1963 the bluetongue transmission research was transferred from Kerrville, Tex., to Denver, Colo.

The Federal scientific effort devoted to research in this area totals 4.9 professional man-years. Of this number, 1.9 is devoted to basic biology, physiology, and nutrition; 1.4 to insecticidal and sanitation control; 0.4 to insecticide residue determinations; 0.4 to insect sterility, attractants, and other new approaches to control; 0.6 to insect vectors of diseases; and 0.2 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

There is a limited program in the States on insects affecting sheep and goats. Research in progress on the control of the sheep nose bot and the sheep ked is providing information useful to the livestock industry. The association of sheep nose bots with disease incidence is being examined. Various new insecticides are being administered to determine their effectiveness in control. Studies of application methods are being performed to obtain more satisfactory results with reduced labor cost and increased treatment safety. General insect pests affecting other livestock as well as sheep and goats are receiving careful attention. Results of studies of the biologies and control of lice and various fly pests are applicable in most cases to all hosts.

There are 0.9 man-years dedicated by the States to research exclusively on sheep and goat insects.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Screw-worm. Research on the screw-worm continued at Mission, Texas, in support of the sterile male release program. A line of traps along the Colorado and Concho Rivers was used to determine the flight range of sterile, laboratory reared screw-worm adults marked with P-32 or dyes. In the initial experiment in May and June 1963, over 1 million flies were released. The most flies were recaptured within 50 miles of the release point, but 1 was trapped at 65 miles, 4 at 80 miles, 2 at 110 miles, 2 at 140 miles, 1 at 165 miles, 1 at 170 miles, and 1 at 180 miles from the release point. These studies indicated that a barrier sterile fly release zone to keep

fertile flies from reaching Texas would need to extend at least 200 miles into Mexico. Additional studies showed that flights in hot weather (June and July) were relatively short and that maximum dispersal occurred in spring and early summer, and again in September and October.

Research was continued to find and develop genetically distinct strains of screw-worm flies. In one study, about 229,000 adults of the Florida strain were examined for inheritable characters. Breeding and backcrossing studies with candidate mutants showed the presence of several strains. Tretamine (a known chemical mutagen) and irradiation were used to induce mutations. In these studies, 23 new strains were produced. Six strains showed unusual larval characters, involving the number of spiracles or the spines on the 11th abdominal segment. All strains were studied for hardiness and competitiveness and 7 strains discarded when they showed no promise of ever becoming suitable for field use.

Through the SAG test, a technique reported previously for determining mating aggressiveness of sterilized or mutant screw-worm flies, it was determined that one strain of Texas screw-worms contained highly competitive males. Male flies produced in the plant operated by the Animal Disease Eradication Division on beef lung were as aggressive as males from the Entomology Research Division's research colony reared on the standard horse meat diet. Male flies reared in an experimental hydroponic medium were also equivalent in mating ability to flies reared on horse meat.

Studies were continued on the effects of desiccation, starvation, and age of flies at time of release on survival. In studies with a substrain of the original Florida strain of flies selected for resistance to starvation (food and water), adults of the 16th to 19th generations survived as well for 96 hours as the original strain survived for 56 hours. At about 50 hours of starvation, 50% of the unselected strain flies were dead, but only 0.3 to 1.7% of the 19th generation of the new substrain. Sexual aggressiveness of the males in the new substrain appeared normal until the 20th generation when a drop of aggressiveness occurred.

A possible taxonomic difference between laboratory-reared screw-worms and wild screw-worms has been found. Further studies are needed to determine whether this larval characteristic is statistically valid.

In studies of effects of low temperatures, young larvae were less tolerant and pupae 5- to 7-days old were more tolerant than mature larvae. Adults exposed to low temperatures showed greater tolerance at 1 to 2 hours of age, as compared with those 1 to 8 days of age. Some abnormal adults were produced when pupae were held at low temperature.

2. Biting Flies and Gnats. It was previously reported that snipe flies annoying sheep and other animals in the coast range of Oregon were of the genus Symphoromyia, and that a few larvae collected were believed to be of that genus. In the past year, 78 additional larvae were collected and 22

emerging flies tentatively identified as Symphoromyia atripes or near atripes. All the larvae were collected within about a dozen feet of water in well-drained, non-compacted biome; some were in moss-covered soil, some in soil under thick clumps of blackberry canes, and some around the bases of alders and willows. The maximum length of larvae collected was around 15 mm. Most larvae were full-grown when collected, but half-grown larvae were in samples taken in the latter half of June. First pupation occurred in the laboratory on May 13; emergence at 76°F. has been from 7 to 13 days after pupation, with a median from 9 to 10 days.

Symphoromyia commonly collected in the Nashville, Oreg. area run to atripes in existing keys, but probably most are not S. atripes, and should be designated S. atripes complex. First adults were collected on June 16 near Corvallis and alongside Upper Drift Creek about 8 miles from Waldport. In July, it was found that the females were attracted not only to the collector, but also to other Symphoromyia females. Caged, living, newly-collected females and the collector were about equally attractive to free females. Seven hundred thirty-one females were collected on July 31 without finding a male, and males have not been collected in previous years. The males of this genus are reported to form mating swarms, but none was seen. The females were sometimes observed crawling over the surface of the ground in known larval habitats, and it is suspected they may have been preparing to oviposit.

Extensive searching near Evanston, Wyo., failed to discover snipe fly larvae, despite the presence of a few adults. However, larvae were found in moss and top soil in a Bear River meadow in Utah (20 to 25 miles from Evanston, Wyo.) at an elevation of 9100 feet. Five larvae were found near the base of new spring growth of false hellebore, in the shade of tall willow bushes, within 3 feet of a small creek that flows into Bear River. The larvae were in the upper quarter inch of soil, directly under several species of flat-growing mosses that were less than 2 inches in height; one larva was found in each 3 or 4 square feet of shredded soil. Indications that mice, shrews, chipmunks, and pocket gophers had dug the soil in this snipe-fly breeding area suggest that these rodents play a role in natural control of snipe flies.

B. Insecticidal and Sanitation Control

1. Screw-worm. Research was continued in Texas to develop more effective insecticides for controlling screw-worms affecting livestock. Fifty-two new compounds were screened for larvicidal effectiveness at 10, 1.0, and 0.1 ppm in screw-worm larval medium. None of the compounds were effective at 0.1 ppm but ENT-25612, ENT-25780, and Monsanto CP-40294 killed all the larvae in 24 hours at 1.0 ppm. In field tests in Mexico, cattle infested with 1-, 2-, 3-, and 4-day old screw-worm larvae were sprayed with 0.05, 0.1, 0.15, 0.2, and 0.25% Shell Compound 4072, or with 0.25% coumaphos (Co-ral) at 2 1/2 gallons per animal. One day after treatment, no live larvae were found at 0.2 and 0.25% Shell Compound 4072, but some of the

cattle were poisoned. A few larvae survived in cattle sprayed with coumaphos and lower concentrations of Shell Compound 4072. Shell Compound 4072 at 0.1% and higher provided screw-worm control superior to 0.25% coumaphos. In a field test in New Mexico, dusts of 5% coumaphos and ronnel (Korlan) failed to afford 100% control of 1- and 2-day old screw-worm larvae in wounds on cattle, when applied by automatic duster.

2. Lice. In Texas, two herds of freshly-sheared Angora goats on two ranches were sprayed in March and April with 0.1% Shell Compound 4072. Biting lice were heavy on both herds and sucking lice light on one before treatment. One herd of 230 adult goats and 168 kids were treated with 100 gallons of spray and another herd, 82 goats and 30 kids, with 25 gallons of spray. No live lice were found on either kids or goats 1 day or 1 week after treatment. By September both herds of goats were heavily to moderately infested again with biting lice and one was also lightly infested with sucking lice. The large herd was sprayed with 100 gallons of 0.3% Ciodrin. At 1 day after treatment, no live biting lice were seen, but there was no apparent reduction in sucking lice. However, after 1 week, no live lice were found. By March 1964, the herd was lightly infested with biting lice, but no sucking lice were noted. One group of 150 nannies were sprayed and 90 kids dipped with 0.03% diazinon suspension. Another group of 74 adult goats and 37 kids was treated in the same manner, using 0.03% diazinon emulsion. At 24 hours and 1 week posttreatment, no live lice were seen on the animals examined in either group. The other herd of 102 newly-sheared nannies and 38 kids was heavily infested with biting lice. The nannies were sprayed and the kids dipped with 0.15% Ciodrin. At the 24-hour and 1-week examinations, no live lice were found.

On a ranch near Harper, Tex., a flock of mutton and ewe sheep were found moderately to lightly infested with sheep biting lice, Bovicola ovis. Fifty-four muttons and 51 ewes, all in full fleece, were sprayed with 100 gallons of 0.13% Ciodrin at 250 psi. The sheep were poorly wetted by the treatment, but at 24 hours posttreatment, an estimated 50 to 75% of the lice were dead. At 1 week and 1 month after treatment, no live lice were found.

3. Ticks and Keds. In Oregon, a small flock of lambs lightly infested with sheep keds was treated with a 5% solution of barthrin in corn oil. Each lamb was treated with 12 ml. of the barthrin solution, applied at random with a pump oil can. Control was over 80% in 3 weeks.

C. Insecticide Residue Determinations

1. Residue Studies. In Texas, gas chromatographic methods were perfected for the determination of Shell Compound 4072 in animal tissues. Analyses of tissues of animals 7 days after being sprayed with 0.25% of Shell Compound 4072 showed residues of 0.085 ppm only in the omental fat. None could be detected after 28 days.

2. Toxicity Studies. Research was conducted in Texas in cooperation with veterinarians of the Animal Disease and Parasite Research Division on the acute and chronic toxicity of insecticides and other chemicals.

A study to determine the interactions of Vitamin A and phenothiazine/lead arsenate drenches with coumaphos was reported for FY 1963. During FY 1964 studies on blood from those animals included the effects on the Vitamin E of plasma and the Vitamin A and carotene of plasma. There are no significant differences between treatment groups for Vitamin E or for carotene. Vitamin A and carotene values decreased throughout the test in all groups. Plasma Vitamin A was affected by two interactions of treatments. With contaminated coumaphos (Co-ral), animals fed normal diets had lower mean values than those fed additional Vitamin A, whereas those animals treated with normal coumaphos showed no differences in plasma Vitamin A, whether supplemented with A or not.

Atropine, the standard antidote for poisoning by organophosphorus compounds, acts by opposing the stimulation resulting from accumulation of acetylcholine but does nothing to treat the basic biochemical lesion, the inhibition of the essential enzyme, cholinesterase. A need for an antidote that would reactivate inhibited cholinesterase has been recognized for many years. Various oximes have been proposed and have shown beneficial action together with specificity toward both compounds and species of animal. In previous studies, the oxime dosages employed did not seem useful against coumaphos poisoning.

A new oxime, TMB4, has been considerably more effective than previously studied oximes in preventing death and hastening recovery of coumaphos-poisoned cattle.

Although carbamate insecticides inhibit cholinesterase, as do organic phosphorus compounds, the process is by carbamylation instead of phosphorylation. Laboratory animal studies indicated that oximes such as 2-PAM intensified the action of carbaryl instead of reversing the enzyme inhibition. Phenothiazine derivatives have some potentiating effects in organic phosphorus insecticide poisoning.

Performance standards have been established for emulsions, but not for suspensions. Analyses of dips made with coumaphos, ronnel and Ciodrin were performed. Ronnel performed extremely well, maintaining its concentration precisely during the dipping of 65 sheep in a 600-gallon vat. Ciodrin was a complete failure, the concentration being reduced by more than 60% by the passage of 52 sheep through a 700-gallon vat. Coumaphos showed an essentially uniform tendency to increase in concentration, indicating that sheeps' wool was selectively absorbing more water than toxicant.

The use of present insect chemosterilants for the control of insects must be restricted because of their potential hazards. Although none of these materials are yet approved for use, studies were continued in sheep to

determine the hazards to livestock. Previous reports have emphasized the radiomimetic effect produced by apholate, tepa, and metepa, particularly the deleterious effect upon the tissues that form white blood cells.

Further studies have shown a second effect, teratogenesis - that is, the production of monstrosities and defects in the young of animals. A lamb born to a ewe fed apholate showed a total lack of eyes and eye nerves, a lack of upper jaw and nose, and numerous other anatomic defects, not the least of which was a total failure to develop a spleen.

A test was completed with a single survivor of a group of four sheep given 1.0 mg/kg of apholate daily. This sheep survived 759 daily doses and the principal effect of apholate was a reduction of white blood cells and blood platelets. Recovery from these deficiencies has been very slow and is still under study.

Ewes and rams fed a dosage of 0.5 mg/kg of apholate were bred during the feeding period. Ovarian and testicular biopsy tissues did not show evidence of damage by apholate and the ewes lambed normally. White blood cell numbers were slightly reduced. The test was terminated after 494 daily doses had been administered.

A second study was designed to show hematologic and teratogenic (deformity producing) effects that might occur with the feeding of apholate. Rams and ewes were selected, placed on diets containing a dosage of 1.0 mg/kg of apholate and allowed to breed. Three of four test ewes, and both control ewes, delivered normal lambs. One test ewe delivered a deformed lamb.

The deformed lamb showed a lack of eyes and eye nerves, nose, and shortened upper jaw. There was no spleen and the liver was rudimentary in size. A mass outside the body resembled liver. The dam of this lamb had received approximately 189 daily doses of apholate at the time of conception and the lamb was delivered after 345 daily doses had been given.

Research has continued on the treatment of animals poisoned by organic phosphorus compounds. Various oximes were studied for their effectiveness alone or in combination with atropine. Pralidoxime chloride (Protopam chloride) showed good effectiveness alone and in combination with atropine, particularly when the dosage of pralidoxime was kept high and repeated. TMB4, a relatively new compound, gave good results in the treatment of coumaphos poisoning, usually the most difficult to control.

D. Insect Sterility, Attractants and Other New Approaches to Control

1. Screw-worm. In Texas 22 of 158 compounds screened as chemosterilants caused sterility in one or both sexes of screw-worm when administered as topical treatments or fed to adult screw-worm flies. Some of the compounds sterilized by both methods of administration. About 18 additional compounds were sufficiently promising in screening to warrant further testing. The

sexual vigor and longevity of males sterilized with ENT-50106 or ENT-50450 were reduced but that of males treated with ENT-50716 or ENT-50842 was not affected.

Higher dosages (whether topical or oral) of the chemosterilant, metepa, are required to sterilize screw-worm flies than stable flies. This verifies conclusions drawn from 1962 studies in which screw-worm flies metabolized metepa faster than stable flies and the sterilizing dose was therefore assumed in 1962 to be higher for screw-worms than for stable flies.

When screw-worm cases occur at places more than 100 miles from the known overwintering zone, the question arises about the possibility of sterilized flies recovering from radiation effects. Special tests were therefore made with flies irradiated as 5-, 5 1/2-, and 6 1/2-day-old pupae with 6200 r. Observations of flies were maintained for 22 days until 95% had died of old age--but none recovered their fertility. Cytological studies of the testes and ovaries of flies treated in this manner up to 31 days old showed a continued degeneration of both testes and ovaries, with no regeneration of germinal tissue. It seems positive, therefore, that the present method of irradiation produces permanently sterilized flies.

Further cytological studies showed the effects of a chemosterilant, tretamine, and gamma irradiation in the screw-worms to be similar, except at the first level of meiosis. Radiation of screw-worm oocytes resulted in many chromosomal aberrations during the 1st and 2nd meiotic divisions of the newly laid eggs; treatment with tretamine, however, resulted in normal-appearing meiosis, followed by visible chromosome damage during cleavage in the embryo larva.

In Texas, approximately 90 chemicals and other materials were screened as screw-worm attractants. Of these, 10 were equal to or better than the standard liver bait and require further evaluation. One of the ten materials, ENT-26926X was highly attractive in some tests, but failed in others. A slightly detectable flowery odor suggested the presence of an impurity, believed to be ethyl isovalerate. Ethyl isovalerate synthesized at Mission and believed to be about 66% pure, was very attractive in several laboratory and field tests. Methyl isovalerate was less attractive. Most of the other 9 promising materials were choline derivatives. Several of these were highly attractive in laboratory and preliminary field tests. An attempt was made to locate pheromones in screw-worms. There was no evidence of a pheromone that would attract males to virgin females, but there was considerable evidence that there may be a pheromone produced by males that is attractive to virgin females.

E. Insect Vectors of Diseases

1. Biting Flies and Gnats. Studies were continued in cooperation with the Denver, Colo., laboratory of the Animal Disease and Parasite Research Division, on the transmission of bluetongue disease of sheep. Attempts to transmit bluetongue from sheep to sheep with Culex tarsalis mosquitoes were unsuccessful. Suspensions of Culicoides variipennis and Culex

tarsalis placed on lamb kidney cell tissue culture monolayers did not cause cytopathological effects in the tissue cultures. Culicoides and C. tarsalis adults were inoculated with tissue culture fluid containing bluetongue virus without undue mortality of the test insects. When C. variipennis that had been intrathoracically inoculated with tissue culture virus were ground and suspended and added to clean tissue culture monolayers, no virus was recovered if the suspensions were added to the tissue culture on the first day. However, after incubation for 10 and 13 days in the Culicoides before adding to the clean tissue culture, the virus was recovered from the tissue culture. This indicated that the virus inoculated into the Culicoides actually multiplied in the insect. Further studies verified the multiplication of bluetongue virus in injected Culicoides; the amount of virus tissue culture fluid injected in a Culicoides variipennis adult was less than 0.0002 grams. It was also demonstrated that bluetongue virus multiplied in Culicoides following blood feeding on an infected sheep. After incubation for 8 days (intrathoracically inoculated adults), the strain of bluetongue virus adapted to chick embryos was transmitted from egg to egg.

Sheep-baited animal trap studies in Colorado and South Dakota indicated that Culicoides variipennis, Aedes nigromaculis, and Culiseta inornata commonly attacked sheep. The following were taken while engorging on a staked sheep: 1 Leptoconops sp., 1 Chrysops sp., and 1 species of Simuliidae. Other field studies in South Dakota verified the frequency of attack of sheep by C. variipennis, A. nigromaculis, and C. inornata, and found two other species that also commonly attacked sheep: Culex tarsalis and Psorophora signipennis. Near Hudson, Colo., in a severe bluetongue outbreak, the virus was isolated from both sheep and cattle and massive C. variipennis breeding was located nearby.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Basic Biology, Physiology, and Nutrition

Baumhover, A. H. 1963. Influence of aeration during cobalt^{60} irradiation of screw-worm pupae. J. Econ. Entomol. 56: 628-631.

Gingrich, Richard E. 1964. Nutritional studies on screw-worm larvae with chemically defined media. Ann. Entomol. Soc. Am. 57: 351-360.

Hightower, B. G. and Alley, D. A. 1963. Local distribution of released laboratory-reared screw-worm flies in relation to water sources. J. Econ. Entomol. 56: 798-802.

Hightower, B. G. 1963. Nocturnal resting places of the screw-worm fly. J. Econ. Entomol. 56: 498-500.

LaChance, Leo E., Riemann, John G. and Hopkins, D. E. 1964. A reciprocal translocation in Cochliomyia hominivorax (Diptera: Calliphoridae). Genetic and cytological evidence for preferential segregation in males. Genetics 49: 959-972.

LaChance, Leo E. 1963. Enhancement of radiation-induced sterility in insects by pretreatment in CO_2 + air. Int. J. Radiation Biol. 7: 321-331.

Insecticidal and Sanitation Control

Chamberlain, W. F. 1964. The metabolism of P^{32}-labeled Alpha Shell SD-4294 in a lactating goat. J. Econ. Entomol. 57: 329-331

Chamberlain, W. F. 1964. The metabolism of P^{32}-labeled Shell SD-4294 in a lactating ewe. J. Econ. Entomol. 57: 119-121.

Insect Sterility, Attractants, and Other New Approaches to Control

Chamberlain, W. F. and Barrett, G. C. 1964. A comparison of the amounts of metepa required to sterilize the screw-worm fly and the stable fly. J. Econ. Entomol. 57: 267-269.

Crystal, Maxwell M. 1963. The induction of sexual sterility in the screw-worm fly (Cochliomyia hominivorax) by antimetabolites and alkylating agents. J. Econ. Entomol. 56: 468-473.

Crystal, Maxwell M. 1964. Observations on the role of light, temperature, age, and sex in the response to screw-worm flies to attractants. J. Econ. Entomol. 57: 324-325.

Insect Vectors of Diseases

Foster, N. M., Jones, R. H. and McCrory, B. R. 1964. Preliminary investigations on insect transmission of bluetongue virus in sheep. Am. J. Vet. Res. 24: 1195-1200.

LIVESTOCK ENGINEERING - INSTRUMENTATION
Agricultural Engineering Research Division, ARS

Problem. To meet present day market demand for lean-type meat, producers need objective nondestructive methods and instruments for estimating the amount of lean meat in live animals. Under the present marketing system of subjective estimates of lean-meat-yield, the resulting price represents an average quality. This lack of precision in pricing fails to reward adequately those producers of high quality animals and pays more for low quality than it is worth.

USDA AND COOPERATIVE PROGRAM

A program is underway at Beltsville, Maryland, to develop and provide accurate, practical and sometimes complex instrumentation for specific program needs. The total effort devoted to livestock instrumentation research is 1.7 professional man-years.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

Research Instrumentation

Ultrasonic reflectance measurements were continued on hogs, cattle, and sheep for correlation with yields of meat cuts. Longissimus dorsi thickness of cattle and sheep were statistically combined with liveweight and compared with area and weight measurements from cattle and sheep. The multiple correlation of ultrasonic measures and liveweight were: with cattle Longissimus dorsi area, 0.35; with cattle weight yield of round, rump, and loin, 0.95; with sheep weight of trimmed or untrimmed leg, 0.95. Yield predictions, based on liveweight, were improved by adding the ultrasonic measures. A recently available bio-medical pulse-echo instrument was trial used and compared with existing unit. Some advantages were observed in respect to convenience; however, the operation principle is basically the same as presently used equipment.

II. NUTRITION AND CONSUMER USE RESEARCH

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are changing constantly with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs in nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas total 63.3 man-years. It is estimated that approximately 0.9 man-years is concerned with studies related to lamb and lamb products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient Value of Food

Food composition and nutritive value are most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

The form of fats and lipids in food stuffs and the changes involved in processing and holding are receiving special attention as the role of different types of fat in human nutrition unfolds. Protein content and structure continue as active research areas.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in food stuffs as affected by inhibitory and stimulatory factors.

The total program in this area includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

The major research in product development is on the production, processing and storage of beef, pork, lamb, poultry and eggs. Variables which affect the initial product, include feeding regimens, age and breed, are under study. Conditions of processing relate to freezing temperature, storage temperature and time, shelf life, and the effect of light.

Other research includes the quality of meat tenderness as influenced by chronological age, post-mortem aging and in relation to connective tissue. Genetic factors which may be operative in establishing carcass characteristics is being investigated in sheep.

Food preparation research focusing on products for home use include: Heat penetration of meats and baked products and the chemical changes involved; microwave preparation of meats, fruits and vegetables, including the chemical alterations involved; and flavor characterization in frozen and stored products by means of vapor component identification.

Many of these same factors are under study in institutional preparation where the quantities involved impose special conditions.

This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to segments of the population or to geographic areas not separately identified in the nationwide studies. Currently twelve States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with preschool children. This group represents about one-fourth of the households in the North Central Region where the study is being made. Food habits will be evaluated in terms of the children's dietary needs. This research will provide information useful to both consumer and market interests.

The State program in this are totals 22.2 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8 "Composition of Foods... raw, processed, prepared" has been supplemented during the year and adapted to the needs of special projects.

Formulas and procedures that were used in calculating the nutritive values of 250 food items commonly prepared at home are being summarized in a publication for special users, particularly therapeutic dietitians and medical research workers. A table showing average adjustments for vitamin losses during cooking has been developed and will be included in the publication.

Selected data from revised Handbook 8, have been made available in decks of punched cards and magnetic tape for research workers. Available in these forms are the data from Table 1, the nutritive values for 100 grams edible portion of the foods; from Table 2, nutritive values for one pound of food as purchased; from Table 3, selected fatty acids in foods.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.

2. Vitamins. Analyses for the vitamin B_6 content, and distribution in meats, including lamb, and in vegetables available to and as eaten by consumers, are in progress. Analyses of cereal foods, fruits, nuts, and cheeses are nearly completed and manuscripts are in preparation.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B_6. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B_6 in foods.

Development of coordinated procedures for B-vitamin analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

B. Properties Related to Quality and Consumer Use of Lamb

1. Freezer preservation of meat in the home. A publication on "Freezing Meat and Fish in the Home," was prepared in cooperation with the U. S. Department of Interior. It presents the latest recommendations on freezing techniques, storage time, thawing, and cooking. The bulletin points out that for high-quality frozen food it is necessary to have home freezing equipment that freezes food quickly at 0° F. or lower and maintains these temperatures for storage of frozen products. Too high or constantly changing storage temperatures cause even frozen foods that are properly packaged to lose quality and food value. Illustrations show how to cut and bone beef, pork, and lamb and how to wrap these products for the freezer.

2. Food distribution program. Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of cereal, dairy, fruit, vegetable, meat, and poultry products were updated to take into account recent research findings and technology. New recipes were laboratory tested and taste panel evaluated, and all formulas and serving yields were recalculated in line with the 1964 revision of PA-270, Food Buying Guide for Type A School Lunches.

C. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals. A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individuals in the households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C. during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group: (1) the nonresponse rate on food intakes from individuals is not influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families. A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis

will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Divisio ERS to assist the AMS to administer the food stamp and direct distribution programs.

3. Food consumption of the rural population in Spain (PL 480 research). A survey of the food consumption of the rural population in Spain has been initiated by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using PL 480 funds. The study will provide information needed in appraising potential markets in Spain for U. S. farm products and should yield information useful to U. S. authorities on efficient ways of improving nutrition in low-income areas. The Spanish Ministry of Commerce expects to obtain much useful information on which to base a program for improving the diets of rural families, especially through better distribution of food. Information on food consumption, income levels, and related socio-economic characteristics has been obtained from about 1,200 rural families in 6 major regions of Spain. In summarizing the results, emphasis is being placed on (1) determining the nutritional shortages among these rural families at different income levels in the different regions, and (2) computing income elasticities for different foods as well as total food consumption.

4. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched.

For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

5. Household practices in home freezer management. Recording forms and questionnaires for obtaining data on management practices of urban and rural home freezer owners were pretested and necessary revisions were made in preparation for data collection among households in Fort Wayne and a nearby rural area. Information will be obtained in two seasons on the kinds, amounts, sources, prices, and turnover rates of frozen foods stored in the home. Such data will provide information needed to develop guidance materials for improved management of home freezers.

6. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Food budgets at different cost levels for individuals and families are priced quarterly for publication in Family Economics Review as a continuing service to welfare workers, extension agents, and others needing this information. For example, in June 1964, the cost of one week's food for a family of four including 2 school-aged children, was estimated to be $24.40, $32.80, and $37.40, respectively, for the low-cost, moderate-cost, and liberal plans.

The food budgets published in Home Economics Research Report 20, "Family Food Plans and Food Costs," have been reexamined in the light of revisions in food composition data (Handbook 8, revised) and in recommended dietary allowances of the National Research Council. Some modification in food quantities was needed. This has necessitated revision of food plans and their presentation in technical and popular publications, including Agriculture Handbook 16, "Planning Food for Institutions," now being readied for publication. The "Food Purchasing Guide for Group Feeding," formerly a part of Agriculture Handbook 16, is in the final stages of editing for publication as a separate handbook.

All other existing guidance materials for nutrition programs were reviewed in light of the changes in recommended dietary allowances and in food composition data. Some publications have been revised; others will be updated for the next reprinting.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Labels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Nutrient Value of Food

Watt, B. K., and Merrill, A. L. April 1964. Composition of Foods...raw, processed, prepared. Agriculture Handbook No. 8. Revised December 1963. 190 pp.

Watt, B. K. April 1964. Revising the Tables in "Agriculture Handbook No. 8." J. Am. Diet. Assn. 44(4): 261-263.

Leung, W. W., Pecot, R. K., and Watt, B. K. May 1964. Tables of the Composition of Foods for the Armed Forces. Department of Defense. Defense Supply Agency. 50 pp.

Consumer and Food Economics Research Division. Revised 1964. Nutritive Value of Foods. Home and Garden Bull. 72.

Consumer and Food Economics Research Division. 1963. Conserving the Nutritive Values in Foods. Home and Garden Bull. 90. 16 pp.

Camarra, R. T., Polansky, M. M., and Toepfer, E. W. 1963. Pyridoxine determined fluorometrically as pyridoxal cyanide compound. Paper presented at the annual meeting of the Assoc. of Off. Agric. Chemists, Washington, D. C.

Toepfer, E. W., Polansky, M. M., Richardson, L. R., and Wilkes, S. 1963. Comparison of vitamin B_6 values of selected food samples by bioassay and microbiological assay. J. Agric. and Food Chem. 11, pp. 523-525.

Properties Related to Quality and Consumer Use

1963. Freezing meat and fish in the home. Home and Garden Bulletin No. 93, 23 pp., illus. (Animal Husbandry Research Division, Human Nutrition Research Division, and Bureau of Commercial Fisheries, Department of Interior cooperating.)

Dawson, E. H., Brogdon, J. L., and McManus, S. 1963. Sensory testing of differences in taste. Part I. Methods. Food Technol. 17(9): pp. 45-48, 51, illus. Part II. Selection of panel members. Food Technol. 17(10): pp. 39-41, 43-44, illus.

Eisen, J. N. 1964. A note on orthogonal polynomials applied to treatment levels with unequal replications. Food Science 29(1): pp. 105-108.

1964. Food buying guide for type A school lunches. Agricultural Marketing Service; Agricultural Research Service; and Fish and Wildlife Service, U. S. Department of Interior cooperating. PA-270, 75 pp.

Food Consumption and Diet Appraisal

Adelson, S. F., 1963. A 2-week vs. a 1-week Reference Period in Surveying Diets of Individuals. Abstract in Proceedings of Sixth International Congress on Nutrition, Edinburgh: p. 477.

Consumer and Food Economics Research Division. 1963. "The Nutritional Review." National Food Situation, No. 106, Outlook Issue, Nov.

Friend, B. 1963. Enrichment and Fortification of Foods, 1957-61. National Food Situation, No. 106, Nov.

Adelson, S. F., Delaney, I., Miller, C., and Noble, I. T. 1963. Discard of Edible Food in Households. Jour. Home Economics 55(8): 633-638.

Redstrom, R. A., Davenport, E. and Murray, J. 1963. Consumer Practices in the Handling and Storing of Commercially Frozen Foods, Two Cities, Two Seasons. Home Economics Research Report 23, 27 pp.

Consumer and Food Economics Research Division. Cost of 1 Week's Food at Home. Family Economics Review. Sept., Dec. 1963; April, July 1964.

Consumer and Food Economics Research Division. 1964. Family Food Budgeting...for Good Meals and Good Nutrition. Home and Garden Bull. 94.

Nutrition Program News (periodical, 5 issues): July-Aug. 1963; Sept.-Oct. 1963; Nov.-Dec. 1963; Jan.-Feb. 1964; Mar.-June 1964.

Clothing and Housing Research Division, ARS

Problem. To choose wisely from the wide variety of textiles available on today's market, consumers need information on the properties imparted to textiles by wool and other fibers and on the properties textiles need for satisfactory performance in specific uses. Also needed by consumers are improved sizing systems for patterns and ready-made clothing, including shoes, and designs for garment features that will contribute to the comfort, safety, and efficiency of the wearer. To provide guidance to homemakers in keeping the family's supply of clothing and household textiles in good condition, research-based information is needed on soiling and soil removal, on causes and prevention of fabric deterioration, and on survival of pathogeni and odor-producing microorganisms on fabrics.

USDA AND COOPERATIVE PROGRAMS

Investigations include studies of the relationship of in-use performance of fabrics of wool and wool blends with laboratory determinations of such properties as elastic behavior and resistance to abrasion. Principles of construction for use in making, repairing, or altering clothing and household textiles are developed. Anthropometric data are obtained as a basis for the sizing of apparel, including shoes. Also investigated are the nature of soil and its removal from fabrics; the nature, causes, and prevention of undesirable changes in fabrics; and the role of fabrics in the dissemination of microorganisms and means of control.

The Federal scientific effort devoted to research related to wool and leather products totals approximately 4.0 professional man-years. The Department's research facilities are located in Beltsville, Maryland.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The States are engaged in both basic and applied research on textile fibers and properties and on the end-use performance of fabrics, clothing and household items.

Projects deal with the comfort of clothing of varying fiber content, with consumer questions relative to wool blankets and soft floor coverings, and with the relationship of price to quality characteristics of various items. More understanding of consumer behavior in relation to price and quality is sought to meet the needs of expanded consumer education programs.

PROGRESS--USDA AND COOPERATIVE PROGRAM

A. Performance of Fabrics for Clothing and Household Textiles

Plain knit wool fabrics are being manufactured to specification for studies on factors affecting the elastic behavior and dimensional stability to laundering of such fabrics. The fabrics are being knit under contract by the Philadelphia School of Textiles and Science from three sizes of yarn, with and without a WURLAN finish applied by WU, with varying numbers of courses per inch.

B. Anthropometric Measurements Basic to the Sizing of Clothing

A search for information pertaining to the sizing of children's shoes was completed and an annotated bibliography on measurement of the human foot prepared. It was found that a comprehensive study of the dimensions and contours of the feet of American children is urgently needed as a basis for improved sizing systems for children's footwear. Preliminary plans for such a study were made at a conference in which specialists in child development, anatomy, orthopedics, nutrition, physical anthropology, and clothing participated, along with representatives of the shoe and last industries. Research to design instrumentation and develop procedures needed for the study was initiated through contract with the University of Rochester.

C. Transmission of Microorganisms by Textiles and its Prevention

Using Staphylococcus aureus as a test organism, the influence of fiber type (including wool), fabric construction, water temperature, and type of natural soil on redeposition of bacteria on fabrics is being studied under controlled conditions which simulate home-type laundering.

Research was initiated to determine whether microorganisms of importance in household hygiene survive drycleaning and if so, whether they are transferred from one fabric to another during the cleaning process. A variety of wool fabrics is being used in this research.

Research was also initiated under contract with the Southern Research Institute for quantitative studies of the survival and infectivity of viruses after inoculation of fabrics by contact, droplet nuclei (aerosols) and dust. Wool fabrics being used are gabardine and blanketing.

D. Information for Consumer Guidance

Manuscripts for two popular-type publications, one on clothing repair and the other on the alteration of patterns as required to meet special problems in home sewing, are in process.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Transmission of Microorganisms by Textiles and Its Prevention

McNeil, E. 1964. Dissemination of Microorganisms by Fabrics and Leather. Develop. in Indus. Microbiol., Vol. 5, pp. 30-35.

Information for Consumer Guidance

Furry, M. S. 1963. Detergents for Home Laundering. Home and Garden Bull. No. 49, 8 pp., illus. (Sl. Rev.)

Furry, M. S. 1964. How to Prevent and Remove Mildew: home methods. Home and Garden Bull. No. 68, 14 pp., illus. (Rev.)

McLendon, V. I. 1964. Removing Stains from Fabrics: home methods. Home and Garden Bull. No. 62, 30 pp., illus. (Sl. Rev.)

McNeil, E. 1964. Sanitation in Home Laundering. Home and Garden Bull. No. 97, 8 pp., illus.

Scott, C. L. 1963. Men's Suits--how to judge quality. Home and Garden Bull. No. 54, 31 pp., (Sl. Rev.)

WOOL AND MOHAIR - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. Traditional markets for wool and mohair have been lost to synthetic fibers because consumers prefer garments that hold their pleats and creases, resist shrinkage and wrinkling during washing, and dry quickly. Natural wool and mohair outclass the synthetics in tailorability, comfort in wear, appearance, and hand, but demand certain features now being exploited by the promoters of synthetics. Furthermore, some current processing damages, distorts, or weakens wool and mohair fibers and injures performance and appearance of fabric. We need processes that will modify natural fibers to give a range of comfortable and attractive fabrics that resist deterioration in processing and wear. Fabrics must be durably resistant to wear, wrinkling, pilling, abrasion, yellowing, soiling, felting and relaxation shrinkage, acid and alkali weakening, insects, and microorganisms. New markets would develop for new types of fabrics, woven and non-woven, for industrial and other uses, made with natural wools and with blends of wool with modified wools or other fibers. Wool could have a part of the new, rapidly developing market for stretch fabrics if we could practicably impart permanent stretch into wool yarn. Research toward such developments requires fundamental information on the chemical, physical, and structural nature of natural fibers and their modified products.

To sustain a stable sheep and wool industry in the United States, mills must be supplied with processing information on new and improved wool and mohair products. Synthetics have cut into wool markets because they are uniform in price and quality and because detailed processing information is available from producers.

USDA AND COOPERATIVE PROGRAM

The Western Utilization Research and Development Division conducts a broad basic and applied research program on wool and mohair to develop new and improved fibers and fabrics that can increase markets. Fundamental research seeks new facts on chemical and physical properties of natural fibers that may make wool and mohair fabrics more useful and valuable. We use such knowledge to try to modify fibers and fabrics so that they will resist degradation by heat, light, chemicals, staining, abrasion, and insects; wash easily; retain creases; shed wrinkles; and require little care. We seek practical processes for chemical and physical modification of wool and mohair fibers, yarns, fabrics, and felts into products that will increase wool and mohair utilization. In addition, Department scientists make every possible effort to bring research results to the industry through technical publications, public service patents, popular articles, TV and radio broadcasts, participation in growers' and processors' meetings, exhibits, mill visits and development trials, and conferences with visitors from the industry.

The Federal program is conducted at the Division headquarters at Albany, California by contract in Durham, North Carolina and Washington, D. C., and by grant funds under P.L. 480 in India, France, Sweden, England, and Finland.

The Federal program of research in this area totals 32.9 professional man-years, including contract research equivalent to approximately 2.0 professional man-years per year. Of this number 11.2 are assigned to chemical composition and physical properties and 21.7 to new and improved textile products and processing technology. In addition, the Division sponsors research grants under Public Law 480 including five on basic studies and two on the application of research findings.

PROGRAM OF STATE EXPERIMENT STATIONS

Station research related to wool and mohair utilization consists of one study designed to determine the comparative resistance to outdoor weathering of four wool fabrics made from fibers differing in crimp and fineness. A second study deals with the relationship of fiber quality and measurement to wool marketing practices. A third study is directed to providing information on the characteristics and properties of Texas mohair, including determining domestic and foreign attitudes toward utilization of mohair.

The total research effort devoted to wool and mohair utilization research is approximately 0.6 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical and Molecular Properties. Basic physical and chemical investigations continue for the purpose of providing a rational basis for modifying and processing wools and wool fabrics into new and superior products. These studies undertake to locate reaction sites for alteration of fiber properties and to identify specific and type changes in fibers as they are subjected to radiant energy, mechanical manipulation, and chemical reactions.

A method to divide or break up wool fiber into component parts with a minimum of side effects would implement research. Grinding wool fibers in a ball mill at -196° C. fragments the fiber without chemical alteration. Fiber fragments so obtained can be separated by differences in density. A heavy fraction was obtained containing more sulfur, cystine, and proline than the lighter fraction. The lighter fraction is richer in tyrosine and phenylalanine.

Wool protein molecules may also be analyzed by enzyme digestion. Proteinases were used to digest normal wool fibers and fibers that had been coated with synthetic polymers. Partial treatment yielded protein molecule fragments for further study. Protein digestion of coated wool (wool treated with a surface coating or synthetic organic compounds) removed the wool but left

the surface film in a suitable condition for microscopic and electron microscopic studies. The objective of these investigations of surface films is to find means to strengthen surface coatings, while reducing the amount of material in the coatings.

Mild pepsin treatment of wool fibers showed the presence of an enzyme-resistant core in studies supported at the University of Lille in France by P.L. 480 funds. At Lille they separated wool protein into two fractions chromatographically. The major fraction corresponded to alpha-keratins with high molecular weight. Another fraction, 5% or 10% of the treated protein, was very high in glycine but low in sulfur. It was insoluble at pH = 3.9 and is now under further study.

Structural studies clarified a discrepancy between calculated and observed nuclear magnetic resonance data for glycine, a major component of wool by identifying differences between alpha and gamma forms of the amino acid molecule. Paramagnetic resonance absorption curves of glycine and deuterated glycine (that is, glycine in which heavy hydrogen has replaced an atom of normal hydrogen in each molecule) checked the positions assigned to the hydrogens in the glycine molecule.

Isocyanate treatment of wool fibers makes possible a graft between molecules which stabilizes the fiber structure. It is possible to promote intermolecular grafting inside the fiber after treatments which swell the fiber. In the absence of the swelling agents, the grafting is largely confined to the fiber surface. Isocyanate treatment imparts shrink resistance and alkali resistance to wool fibers. Intermolecular grafting of wool fiber molecules and intermolecular polymerization with polystyrene was enhanced by high energy radiation from radioactive cobalt and from a 3 million electron volt accelerator in contract research at the Triangle Research Institute in Durham, North Carolina. The grafting could be confined to the surface or promoted throughout the fiber interior by adjustment of the water content.

2. Physical and Mechanical Properties. Advances were made in developing objective physical methods for measurement of fabric and fiber properties to provide evaluations that are rapid and free from human errors. An analog computer was programmed for 21 parameters of wool fiber stress-strain curves. The output of the program roughly agreed with subjective evaluation of wool fabric hand. Advances were also made in measurement of wrinkle recovery using differences in compressibility of sharp triangular creases in fabrics. In addition, a series of wools were assembled varying in yellowness and grayness to establish color standards.

Standard laboratory test methods have proven insufficient to appraise the wrinkling of fabric during wear. Actual wear trials will be necessary to distinguish between fabrics that are close in performance characteristics. Contract research at the Harris Research Laboratories in Washington, D. C. on a method of subjective visual appraisal of photographs of garments which have been worn shows promise of becoming reasonably sensitive. Several

commercial fabrics were obtained and made into men's slacks for a small-scale service test.

Two series of specially constructed fabrics, worsted and woolen, were designed to include variation in construction factors, such as weave, cover factor, weight, etc. These specially designed and constructed fabrics, including wool-mohair combination yarns will be produced and evaluated to determine effects of construction variables on wrinkle resistance.

3. Effects of Radiation and Other Physical Forces on Wool. Basic research is conducted to explain in detail the breakdown of wool by light to provide information that will allow a rational approach to developing methods for controlling light-induced degradation of wool and wool fabrics. Physical evidence was obtained showing that ultraviolet light ruptures disulfide bonds of wool protein producing a cystine free radical and green discoloration. When pure cystine was exposed to ultraviolet light, the same characteristic electron paramagnetic resonance spectrum appeared and a blue color. The green in wool is a combination of the blue from irradiated cystine with yellow caused by exposure of intact wool to ultraviolet light. The ultraviolet-induced green disappears unless the wool is kept under vacuum and protected from oxygen. The green color and the characteristic EPR spectrum for the cystine radical disappear if the wool is allowed to react with oxygen, water vapor, or gently heated in vacuum.

The effects of heat on wool are studied in detail to learn specific causes of wool's instability to heat and to chemical reagents combined with heat. We observed specific chemical transformations or physical rearrangements of the wool molecule. At temperatures near 160° C., protein chains that had not been tied into a crystalline lattice became mobile. New juxtapositions thus became possible for amine and carboxyl groups. New amide crosslinks formed that restabilized the molecular structure.

B. New and Improved Products and Processing Technology

1. WURLAN. WURLAN is the name of the new interfacial polymerization (IFP) application of polyamides to the surface of wool fiber and fabrics. WURLAN-treated wools are in full-scale commercial production and available in substantial quantity in the textile markets today. Research continues to develop improved or less costly interfacial polymerization treatments. Cooperation with commercial operators led to adoption of new chemicals that reduced reagent costs by 50%.

Research is also conducted to apply the WURLAN treatment to wool at the top stage. The successful extension of interfacial polymerization to wool would strengthen wool's competitive position, especially in knit goods and in fabric blends. It would also provide an alternative treatment for tightly constructed worsteds which are difficult to treat as cloth.

Factors of temperature, pH, reagent concentration, and processing speed were evaluated in WURLAN application to wool top. Three treatment combinations showed adequate shrink-proofing combined with low fiber bonding. One was most promising because results were achieved with a short-time immersion treatment. A 600-pound lot of wool top was treated by this procedure for use in collaborative work for the Clothing and Housing Research Division of the Department. For this large research production, a new chemical control of reagent concentration proved effective and reduced the consumption by more than 50%. Such a reduction, if applicable industrially, would significantly reduce the cost of the process.

Important variables affecting processing costs and product quality for wool top must be more fully defined before the WURLAN treatment of top can be considered completely suitable for routine commercial production. Industrial collaboration in studies will expand and further work will focus on choosing among alternative monomer combinations and processing conditions.

Appraisal of alternative reagents for the IFP treatment continues. Improved shrink-proofing of wool fabrics was obtained when strong bases, such as sodium metasilicate, were used in place of carbonate in the diamine solution of the IFP polyamide system. A slight increase in the flat setting of fabric was noted when thiol reducing agents were used. Various polyamides, polyurethanes, and other copolymers are being applied to fabrics and the treated products evaluated.

Blends of coarse wool with kid mohair top were prepared and WURLANized. Blends with 25% and 50% mohair were spun into coarse count knitting yarn and knitted into fairly open structures. Wash tests on the treated knit samples showed little felting compared to untreated samples.

2. Stretch Woolens. An exploratory study of an all-wool stretch yarn is promising. A combination of chemical and mechanical treatments makes wool fibers helical. The helical fibers are elastic even after repeated load cycling and repeated wetting and drying. Experimental knit and woven constructions were strong. The general procedure was to apply twist on twist to a plied yarn, resin treat, and then back twist past the zero point to a standard twist. IFP and application of preformed reactive polymers both were used to set high twist yarns. Polyamides, polyurethanes, and copolymers applied by IFP and reactive polyethylene resin showed promise. The permanence of the treatment is being tested. The laboratory will produce enough yarn to make fabric for evaluation.

3. Yarn and Fabric Construction. Both yarn and fabric construction greatly affect the performance of fabric and its response to chemical treatments which make care easier. The effect of variations such as weave, cover factor, weight, etc., of worsteds and woolens wrinkling during wear is being investigated in contract research at the Harris Research Laboratories in Washington, D.C. Emphasis to date has been on the development of evaluation techniques (see paragraph A-2).

The mechanism of lubrication of worsted yarns is being investigated by the Hosiery and Allied Trades Research Association in Nottingham, England under a P.L. 480 grant. Work continues on the influence of different amounts of added wax upon frictional properties of the yarn. Apparatus for waxing yarn, knitting it, and measuring frictions involved was modified to make a kinetic yarn-to-yarn friction measurement. Experimental methods and equipment are still being developed in this study and no conclusions can be drawn yet.

We have been trying to discover if WURLAN treated top is suited to the mechanics of ordinary processing. The adhesion of one fiber to another in treated top ranged from satisfactory to highly unsatisfactory depending upon the treating conditions (reagent concentration, time, temperature, and pH). Resin dusting during the processing increased as reagent concentration, temperature, and pH increased. Dusting decreased with longer immersion time. Small lots (10 lbs.) indicated too high pH, temperature, or reagent concentration made the top extremely difficult to draw and spin. The recombing noilage of treated top was not excessive. A dye absorption procedure was found to measure the resin loss during processing. Indications are that this analysis will be a useful tool for controlling production operations.

4. Fiber and Fabric Treatments to Make Care Easier. The commercial success of interfacial polymerization (WURLAN) does not obviate other finishing treatment for wool. Several promising leads for continuous single application, multiple purpose finishing agents are being investigated. Some of the most promising are fluorine-containing synthetic compounds which impart shrink resistance as well as resistance to water and oil. A number of copolymers and long-chain fluorochemicals were synthesized and subjected to preliminary evaluation on wool fabrics. The screening process will continue and the most promising reagents will be subjected to more extensive laboratory evaluations.

Reactive polyethylene finishing resins of two types were screened: reagents used in organic solvents by a dip-pad cure process and those applied in water emulsions by a new crosslinking technique. Both types protected wool against shrinkage at uptakes of reagents as low as a half percent. Application from water emulsion appears adaptable to single-step preformed polymers continuous processes. Water emulsion application of other synthetic chemical reagents is being studied. Products based on new, relatively inexpensive polyethylene resins may extend the range of polymeric finishes.

Treatment of wool with ozone as briefly as 1-1/2 minutes stabilizes the fabri against felting shrinkage. The ozone-treated wool dyes and bleaches faster than untreated wool and retains tensile strength. Fabric abrasion resistance is somewhat lower. The cost of a continuous ozone shrink-resistant treatment appears very low and pilot equipment is now being designed to take this laboratory observation one step further toward commercial use.

A process for high-energy radiation-induced grafting and polymerization of styrene on wool is being investigated by the Research Triangle Institute at Durham, North Carolina. They have discovered basic information on the effects of dose and dose rate on the grafting of polystyrene to wool in the presence of high-energy radiation (see paragraph A-1). They showed that cloth made from grafted fiber lost superficial water faster than untreated cloth and that water diffused into and out of the treated fibers considerably faster. Such a treatment shows definite promise as a practical method for improving drying rates for wool fabrics. Research to date indicates that the radiation grafting may be induced at sites in wool associated with discoloration. If further research bears out these observations, it is possible that such modified wools would have a greater chemical stability to radiation including visible light. Properties of wool fabrics that have been treated by the radiation-induced grafting of styrene, vary considerably with the degree of swelling at the time of treatment. The swelling can be influenced by control of the moisture content of wool. It appears feasible to produce fabrics with a wide range of drying rates to meet specific requirements.

5. Wool Discoloration and its Control. The yellowing of wet baled grease wool is a problem of considerable economic interest. One hundred pound bales of grease wool treated with 1% paraformaldehyde showed little change in temperature or color after three weeks' aging, although the initial moisture content of the baled wool was as high as 40%. Similar untreated bales increased in temperature from 74° F. to 100° F. in five days with a 40% increase in yellowing. Yellowing depended upon moisture content of the wool and there was no discoloration in untreated samples below about 15% moisture. Microbial activity was not found to be the direct cause of yellowing of moist grease wool. However, microbial activity heated the wool and increased rate of yellowing at the higher moisture levels. The paraformaldehyde prevented microbial action.

Contract research was completed on improved bleaching processes for wool at the Lowell Technological Institute Research Foundation in Massachusetts. The research indicated ways to increase brightness of wool through bleaching with peroxide and conditions for minimizing alkali solubility and strength loss. The unscourable discoloration in wool can be bleached, but only at the expense of some damage to the fiber. Chemical crosslinking treatments can reduce the damage, but these treatments in turn reduce wool's abrasion resistance. Crosslinking reagents were evaluated for this purpose. Formaldehyde effectively inhibited the increase in alkali solubility which is otherwise caused in the wool by peroxide bleaching. Additional peroxide was required to compensate for losses through reaction with the formaldehyde. The contractor's recommendation was that wool should be bleached with hydrogen peroxide at pH of 9 to 10 in the presence of tetrasodium pyrophosphate for about 5 to 10 minutes at temperatures between 160 and 180° F. in a continuous process. It was further recommended that alkali solubility of wool

be minimized by pretreatment with alkaline formaldehyde or by addition of formaldehyde directly to the bleach bath.

6. Improved Finishing Treatments for Wool Fabrics. The consequences of interrelationships of different wool finishing processes are being investigated by the Textile Research Association in Helsinki, Finland under a P.L. 480 research grant. This research deals partly with top dyed fabrics and partly with fabrics to be piece dyed. Both kinds of cloth include plain, Panama, and twill weaves made from coarse, medium, and fine wool. Preliminary and pilot plant experiments carried out on fabrics to be piece dyed included scouring and setting treatments prior to dyeing as well as dyeing experiments. The development of proper finish in wool fabric begins early in the processing. Scouring should produce the highest possible degree of homogeneity of fibers in order to improve fabric dyeability. The chemical setting of fabrics must be thorough prior to dyeing and dyeing should be carried out at a low pH. Experiments with simultaneous dyeing and setting resulted in smooth fabric surface but poor dye penetration. Cooperation with the Norwegian Textile Research Institute makes possible simultaneous setting and dyeing in commercial beam dyeing equipment. Much is still to be done to establish the best conditions for both setting and dyeing.

Experiments with top dyeing are also being conducted. The various fabrics of this experiment were each dyed and finished by conventional methods for purposes of comparison with experimentally finished fabrics. With conventional methods, crease recovery values of piece dyed fabrics were always more flexible, more easily elongated by low load than top dyed fabrics. The differences between piece-dyed fabrics and top-dyed fabrics were less in coarse fabrics than fine cloth.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

Bartulovich, John J. 1964. Disintegration of wool at low temperature and its fractionation by density difference. Textile Res. J. 34(5), pp. 461-466.

Bright, Harold J., Lundin, Robert E., Ingraham, Lloyd L. 1964. The mechanism of the methyl-aspartate ammonia-lyase reaction: deuterium exchange. Biochimica et Biophysica Acta 81, pp. 576-584.

Burns, R. H., Johnston, A., Hamilton, J. W., McColloch, R. J., Duncan, W. E., and Fisk, H. G. 1964. J. Animal Sci. 23(1), pp. 5-11. (Contract)

Felix, W. Dale, McDowall, Max A., and Eyring, Henry. 1963. Textile Res. J. 33(6), pp. 465-471. (Contract)

Fletcher, J. C. and Robson, A. 1963. The occurrence of bis-(2-amino-2-carboxy-ethyl) trisulphide in hydrolysates of wool and other proteins. Biochem. J. 87(3), pp. 553-559. 1/

Fletcher, J. C., Robson, A., and Todd, Joan. 1963. The sulphur balance in wool. Biochem. J. 87(3), pp. 560-567. 1/

Menefee, Emory. 1964. Stress relaxation after steady shearing: applications and empirical representation. J. Appl. Polymer Sci. 8, pp. 849-861.

Moschetto, Yves and Biserte, Gerard. 1963. Wool keratins. II. Fractionation of S-carboxymethyl-kerateins by gel filtration; isolation of a new keratin fraction. Bull. de la Soc. de Chim. Biol. 45, pp. 933-950. 1/

O'Connell, R. A. 1963. Graphical solution of wool fineness distribution data. Textile Res. J. 33(9), pp. 758-761.

Stigter, D. 1963. Light scattering by nonideal solutions. Proc. Interdisciplinary Conf. on Electromagnetic Scattering, Potsdam, N. Y., "Electromagnetic Scattering," Pergamon Press, New York, pp. 303-309.

Stigter, D. 1964. Electroosmosis of wet wool. J. Colloid Sci. 19(3), pp. 268-278.

Stigter, D. 1964. Ionic conduction and liquid flow in wet wool. J. Colloid Sci. 19(3), pp. 252-267.

1/ Research supported by P.L. 480 funds.

Tomimatsu, Y. and Palmer, K. J. 1963. Reflection corrections for light-scattering measurements for various cells with the Brice-type photometer. J. Phys. Chem. 67(8), pp. 1720-1722.

Wasley, W. L., Whitfield, R. E., Miller, L. A., and Kodani, R. Y. 1963. Wool stabilization by interfacial polymerization. Part VI. Relative rates of hydrolysis of acid chlorides. Textile Res. J. 33(12), pp. 1029-1032.

Whitfield, Robert E. 1963. Steric factors in the chemistry of polypeptides, poly-alpha-amino acids and proteins. Science 142(3592), pp. 577-579.

Windle, J. J. and Wiersema, A. K. 1963. Electron paramagnetic resonance of naturally abundant N^{15} and S^{33} in peroxylamine disulfonate ion $[NO(SO_3)_2]^{=}$. J. Chem. Phys. 39(4), pp. 1139-1140.

New and Improved Products and Processing Technology

Koenig, N. H. July 1963. Treatment of wool with acid anhydrides in the presence of acetic acid. U.S. Patent No. 3,097,052.

Koenig, N. H. Sept. 3, 1963. Treatment of wool with epoxides in the presence of dimethylformamide. U.S. Patent No. 3,102,774.

Koenig, N. H. October 22, 1963. Treatment of wool with benzyl halides in the presence of dimethylformamide. U.S. Patent No. 3,107,969.

Koenig, N. H. and Crass, R. A. Nov. 12, 1963. Treatment of wool with acid chlorides in the presence of methylpyrrolidone. U.S. Patent No. 3,110,543.

Koenig, N. H. November 12, 1963. Treatment of wool with acid chlorides in the presence of gamma-butyrolactone. U.S. Patent No. 3,110,542.

Koenig, N. H. November 26, 1963. Cyanates in the presence of gamma-butyrolactone. U.S. Patent No. 3,112,157.

Launer, Herbert F. 1963. Effect of light upon wool. III. Post-irradiation loss of color in dark after "Germicidal" UV exposure. Textile Res. J. 33(11), p. 918.

Lundgren, Harold P. 1964. Man modified wool with easy care properties developed. Knitted Outerwear Times 33(9), pp. 25, 37, 38.

Pittman, Allen G. 1963. Use of 1-(Perfluoroacyl)-azirdines in wool. Textile Res. J. 33(11), pp. 953-955.

Pittman, Allen G. 1963. Grafting of poly(1,1-dihydroperfluoroalkyl acrylates) on wool. Textile Res. J. 33(10), pp. 817-824.

Pittman, A. G. and Wasley, W. L. 1964. Fluorine containing polymers for application on wool. Amer. Dyestuff Reporter 53(10), pp. 30-33.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. 1963. Wool stabilization by interfacial polymerization. Part IV. Polyureas, polyesters, polycarbonates and further studies on polyamides. Textile Res. J. 33(6), pp. 440-444.

Whitfield, R. E., Miller, L. A., and Wasley, W. L. 1963. Wool fabric stabilization by interfacial polymerization. Part V: Copolymers. Textile Res. J. 33(9), pp. 752-754.

III. MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY OF LAMB AND MUTTON

Market Quality Research Division, ARS

Problem.

Meat is a very perishable commodity which varies greatly in quality characteristics such as tenderness, juiciness, flavor and fat content. To the consumer the visual characteristics of meat quality are primarily color and fat-to-lean ratio. However, properties such as tenderness, juiciness and flavor cannot be judged so simply. The meat grader attempts to evaluate these quality factors by relating quality to evidences of maturity, texture of the lean, and degree of marbling. To insure more uniform grades and standardized products, better objective tests for measuring the quality attributes of tenderness, juiciness and flavor in meat are needed. Also needed are more effective methods for maintaining optimum quality by minimizing such deleterious effect as shrinkage and bloom and by enhancing the shelf-life of meat as it moves through market channels.

USDA PROGRAM

This work is being conducted at Beltsville, Maryland, with the cooperation of the Animal Husbandry Research Division, ARS, the Livestock Division, AMS, and in part by research contract with the University of Missouri and by cooperation with the University of Illinois. Research programs concerned with the development of new techniques for measuring meat tenderness and for evaluating the composition of livestock, carcasses and meat cuts are underway. The application of the ultrasonic technique to estimate the thickness of backfat and muscling in live hogs, cattle, and sheep is one example of this type of research. Another area of interest is concerned with the use of improved sanitary practices in the merchandising of meat to extend shelf-life and to develop objective methods for the evaluation of quality and shelf-life of prepackaged fresh meats. Studies are also underway to standardize lighting conditions in work areas where meat grading is done.

To augment in-house research at Beltsville a new meat laboratory has been established. Here instrumental techniques in conjunction with classical methods of organic and biochemistry are applied to problems concerned with the evaluation and maintenance of meat quality. Basic information gained at the molecular level concerning proteins, electrolytes, phospholipids,

triglycerides and other meat constituents will be used in attempts to establish objective methods for quality evaluation.

A grant with Robert College, Istanbul, Turkey, provides for the development of an odor-measuring instrument for use in inspection and grading of foods. Its duration is for 5 years, 1961-1966, and involves P.L. 480 funds with a $29,361 equivalent in Turkish liras.

A grant with the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on refrigerated meat. Its duration is 4 years, 1963-1967, and involves P.L.480 funds with a $44,453.40 equivalent in Finnmarks.

The USDA scientific effort devoted to research in this area totals four professional man-years of which one man-year is on contract and 2.5 man-years are in the area of objective measurement and evaluation of quality.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research directed to increasing our understanding of the market quality of meat has been a continuing part of the State stations' research program. Both basic and applied research are involved.

Market quality research on meats begins with study of the influence of breeding, feeding and management treatments with cattle, sheep and swine on the carcass and meat quality characteristics. The objective is to determine the relationships of live animal and management factors to ultimate eating quality. Such live animal traits as birth weight, rate of gain, efficiency of gain by sire groups, body measurements such as depth and length of body, type, market weight and grade are related to carcass traits such as loin eye area, muscling characteristics, amount and distribution of fat, yield of wholesale cuts, chemical composition and carcass value in an effort to define animal traits which influence carcass and meat quality.

Other research involves investigation of various pre-slaughter treatments on the carcass quality, organoleptic characteristics and market value of the meat. Special attention is given to tenderness of meats and the fundamental causes of toughness or tenderness in meats. Certain post-mortem factors including aging exert profound effects on meat quality and considerable effort is devoted to attempts to gain a better understanding of their effects.

Almost all of the studies involve a certain amount of work on methods since methodology is of vital importance in the study of quality factors. Development of objective criteria for evaluation of meat quality is a continuing

goal and new and improved methods of defining the quality of meat cuts are constantly sought.

Further along the route to the consumer, concern arises as to the effects of processing and storage treatments on the quality of meat. The influence of maturity, marbling, methods of aging and processing and storage, packaging and distribution are all studied for possible effects on ultimate quality. Microbial quality, distribution of muscle proteins and lipids, morphological features, amount of connective tissue, and cooking treatment are other factors considered in attempting to establish the total quality characteristics of meat. Finally, the relationships of raw and cooked meat quality to consumer preference are determined. These are in turn related to the carcass quality and market value of the live animal.

A total of approximately 17.7 professional man-years are devoted to market quality research on meats.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Yield of Lean Meat from Cattle of Different Conformation. The study in cooperation with the Livestock Division and the University of Illinois comparing two groups of cattle of different conformation but of the same USDA Quality Grade (Choice) has been completed. Results showed that there were no differences between the yield of lean meat from these two groups of beef carcasses when evaluated according to the system of determining yield developed by USDA. Palatability studies comparing these two groups of carcasses showed no difference in eating quality as judged by a six-member taste panel or by Warner-Bratzler shear determinations. Analysis of the beef carcass data in order to develop correlations and multiple regression equations that can provide guidelines to measurements that account for the greatest amount of variation in yield of lean meat from these wholesale cuts have also been completed.

(MQ 3-34)

2. Measurement of Tenderness. In a study being conducted cooperatively with Animal Husbandry Division the tenderness of cooked loin steaks and rib roasts of beef, representing a range in carcass grade from Utility to Choice are being measured. Subjective tenderness evaluation data are being obtained by taste-panel judgements; objective measurements by Warner-Bratzler shear determinations and measurement on puncture and shear using the Slice-Tenderness Evaluator (STE) developed by USDA. This phase has not reached the stage for reporting findings.

(MQ 3-34)

3. Relationship of Marbling to the Palatability of Beef. This project has been initiated to study the relationships between marbling and composition, concentration and distribution of lipid material in beef muscle. Marbling plus this type of knowledge, or this information alone, may provide a more object method for the evaluation of palatability than marbling per se. This project is in its initial stages and no findings can be reported.
(MQ 3-60)

4. Flavor Studies to Provide a Basis for More Objective Measurements of Meat Palatability. This project has been initiated to develop objective procedures for identifying and evaluating flavor characteristics of meat by studying the compounds and precursor systems responsible for meat flavor. Studies on beef and lamb are underway. A fraction has been isolated from unheated lamb fat that possesses characteristic lamb aroma. This crude fraction has been partially separated and procedures for the quantitative collection of these sub-fractions developed.
(MQ 3-61)

5. Objective Methods for Measuring Maturity. Stages of physiological maturity should be reflected in differences that can be measured at the molecular level in muscle tissue. A comparative study of the proteolytic activity of tissue, from similar muscles, from animals of different chronological age has been initiated in order to see if this measure of enzymatic activity can be correlated with maturity. New analytical procedures are being now developed in order to carry out the objectives of the research project. (MQ 3-62)

6. Odor-Measuring Instrument. This project covers research being undertaken in Turkey under P. L. 480 funds. The investigator came to the United States and discussed the development and research basis for his instrument at a scientific meeting held in Washington on odor measurement.
(A22-AMS-1(a))

B. Quality maintenance in handling and packaging

1. Shelf-life of Prepackaged Meats. The University of Missouri has completed several storage cycles for beef and pork, under the contract, to study the factors affecting the shelf-life of prepackaged meats. Each cycle included different sanitation levels under controlled cutting room temperatures. As a result of this work a revised manual containing new recommendations for temperature, humidity, sanitation and handling procedures for fresh meats is being prepared.
(MQ 2-75)

C. Quality maintenance during transportation

1. Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meat. The first annual report (covering period April 1, 1963 - March 31, 1964) was received under this P. L. 480 research grant. During the report period only one test series with meat kept in normal atmosphere was carried out. The greater part of the report period was consumed in procuring equipment and in trial runs and in developing the chemical and bacteriological methods of analysis.

(E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Carpenter, Z. L., R. G. Kauffman, R. W. Bray, and K. G. Weckel. 1963. Factors influencing quality in pork. B. Commercially cured bacon. Jour. of Food Science 28(5):578-583. (MQ 3-9(c))

Feinstein, Louis and Richard L. Hiner. 1963. Anesthesia and its relationship to body composition. Annals of the New York Academy of Sciences 110:1141-1145. (MQ 3-34)

Hornstein, I. and P. F. Crowe. 1964. Meat flavor - a review. Jour. of Gas Chromatography 2(4):128-132. (MQ 3-61)

WOOL AND MOHAIR - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least $350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used is being questioned, and safer effective treatments are needed. Urgency is attached to this need by the concern about pesticide residues in clothing expressed by the President's Science Advisory Committee in its 1963 report on pesticide use.

USDA PROGRAM

The Department has a continuing program at Savannah, Georgia, involving entomologists and chemists engaged in applied research on the protection of wool and other animal fibers against insect damage. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A grant to the Shri Ram Institute for Industrial Research, Delhi, India, provides for studies on the "canary coloration" of raw wools. Its duration is for 5 years, 1963-1968, and involves PL 480 funds with a $98,454 equivalent in rupees.

The Federal scientific effort devoted to research on prevention of insect infestation totals 1.5 professional man-years. In addition. some of the cross-commodity research at Savannah, Georgia, under the program entitled, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research related to the market quality of wool and mohair is in progress at the Kentucky, Montana, New Mexico, Texas, and Wyoming stations.

The Kentucky program is directed to determining the grade distribution of wool sold in Kentucky and analyzing the grade-price relationships in the various areas of the State. Similar work is involved in programs at the other stations. Montana researchers, for example, seek to determine the relationship of color of scoured wool and colored fiber content of grease

wool to their combing performance and market value. Other research deals with the effect of fiber measurement on the price of wools. Research directed to measuring the effect of outdoor weathering on wool fabrics made from fibers with selected properties is also in progress. One Texas study seeks to determine present domestic and foreign attitudes toward utilization of mohair blended yarns and fabrics and relate these to market qualities.

Total research effort on wool and mohair quality is 3.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. The first progress report has been received and covers the partial collection of analytical data obtained on samples of both yellowing and nonyellowing types of fleeces. The data have not been completely analyzed but cover information on: pH of suint, suint content, grease content, cystine, lanthionine, total and free sulfur content, diameter, medullation, thickness of grease layer, strength and elongation, specialized mechanico-chemical analysis, super contraction, plasticity, set, differential thermal analysis and degree of yellowness. The completed analyses will lay the foundation for undertaking the other phases of the proposed plan of research. (A7-AMS-12(a))

B. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory tests with 54 new compounds failed to reveal any outstanding candidates for further testing. Barthrin and dimethrin appear promising for further evaluation as mothproofing agents on the basis of performance in preliminary tests and because of their extremely low mammalian toxicity as reported thus far. Followup studies on promising surfactants mentioned last year gave results justifying further developmental work. Quaternary ammonium compounds applied to washable woolens in the last rinse water indicated that satisfactory mothproofing properties might be obtained by a home treatment with such materials. The manner in which the rinse water was extracted seemed to have no influence on the effectiveness of the treatment. Better results were obtained in automatic washers than in hand washers. A heat-sealed kraft-polyethylene envelope used by the Armed Forces for stored woolens, and the new Quartermaster clothing container with overtape on all seams, were excellent physical barriers to the entry of fabric pests. (MQ 1-26)

LIVESTOCK, MEAT, AND WOOL - MARKETING FACILITIES, EQUIPMENT, AND METHODS 1/

Transportation and Facilities Research Division, ARS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities--such as livestock auction markets, commercial feedlots, and hotel supply houses. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

1/ The work described here is part of an overall program aimed at improving market facilities and market operations. As agricultural commodities flow through marketing channels they converge with similar products, for example, meat, poultry, fish and dairy products are often handled by the same wholesaler and reach consumers through the meat and produce department of retail stores. Because of this situation, improvements in the overall marketing process can bring about benefits that affect several commodities simultaneously. The component costs of marketing have been rising rapidly and would have risen more if the results of this type of research had not been available. In the marketing of food commodities in 1963, at least $30 billion (75% of the total food marketing bill) were expended on marketing operations that are directly affected by the research covered in the overall program. The overall program includes (1) terminal wholesale marketing planning, (2) preliminary and followup work in terminal market areas, and (3) production area and independent marketing facilities such as that described here. Terminal wholesale market planning was conducted in 7 major cities last year. Production area and independent market facilities planning involved 41 studies. For additional information see "A Summary of Current Program and Preliminary Report of Progress" dated September 30, 1964, by the Transportation and Facilities Research Division, ARS, USDA.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program devoted to planning marketing facilities in which application is made of engineering, economic, and marketing principles. This work is concerned with structures, equipment, containers, devices, work methods, and operating methods used in marketing and transporting farm and food products from farms to consumers. The functions to which these physical elements, handling methods, and labor relate include essentially all marketing operations, especially those directly applicable to the commodities in the physical sense such as assembling, preparing for market, processing, packaging, precooling, loading, transporting, unloading, storing, warehousing, and wholesale and retail distribution. The part of the program pertaining to sheep and wool involves industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meatpackers and wholesalers, and wool warehousemen. Livestock market research is carried on at Hyattsville, Md. Part of the work in this area is being done in cooperation with the Missouri Agricultural Experiment Station, Columbia, Mo., and the Central Missouri Livestock Auction, Mexico, Mo. Work on the development of a mechanical driving device and penning system for livestock markets is under a contract with the American Research and Manufacturing Corporation, Rockville, Md. The research on livestock slaughtering and on meatpacking and wholesaling at Stillwater, Okla., is cooperative with the Oklahoma Agricultural Experiment Station. Wool warehouse research is carried on at Hyattsville, Md.

The Federal effort devoted to research in this area during the fiscal year 1964 totaled 5.3 professional man-years; 2.1 man-years (including 1.8 man-years of contract work) on livestock marketing, 2.3 man-years on meat facilities, 0.2 man-year on wool warehouses, and 0.7 man-year on program leadership.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Automation of Sales Operations on Livestock Markets

At the Central Missouri Livestock Auction, Mexico, Mo., the combination electronic load-cell and lever-system scale, and the scoreboard for flashing total weight, average weight, and price to the audience continues to perform well. The manual-key input device for transmitting sales data from the auctioneer's box to the office and the computer for processing this information could not operate at the speed of the fastest sales transaction. During the year the Toledo Scale Corporation, which provided this equipment, abrogated the Memorandum of Understanding covering this part of the work.

The contractor's report from the Toledo Scale Corporation on the physical and economic feasibility of electrically-operated gates was favorable and provided information on gate structure, latching designs, drive systems, and remote controls. A cooperative agreement was negotiated with the Missouri Agricultural Experiment Station for constructing and testing of prototype electrically-operated pen gates. Working drawings, based on data in the contractor's report, were provided the cooperator. Construction of the prototype gates was underway at the end of the report year and laboratory tests and modifications will continue for several months. Tests of the gates under actual operating conditions will be conducted on the Central Missouri Livestock Auction, Mexico, Mo.

B. Determining Behavioral Patterns of Livestock

Under a contract with the American Research and Manufacturing Corporation, Rockville, Md., research to establish behavioral patterns of cattle, hogs, and sheep under environmental conditions existing on stockyards and auction markets was conducted on a site leased from the Baltimore Union Stockyards, Baltimore, Md. The research involved determining the reaction of each species of livestock to (1) light rays of different candlepower, intensity, and bands of the spectrum, (2) sound of different pitch and intensity, (3) air blasts of different velocities and temperatures, (4) electricity applied at different voltages and by various means, (5) a moving "sweep" or "driver" of alley width equipped with selected devices, including rubber fingers, for prodding animals, and (6) selected combinations of the media listed above. The purpose of this research was to determine the feasibility of driving and penning livestock automatically.

The results of the experiments showed that a mechanical sweep with electrically charged bars was the most feasible device or stimuli for driving and penning livestock. No favorable reaction was obtained from the experiments with light rays. These included mercury vapor lamps, flashing xenon lamps, colored lights (red, blue, green, and yellow), and infrared-heat lamps. Reaction to the experiments with sound ranged from moderate to good. White noise produced the least favorable reaction, sinusoidal sound was better, and the amplified human voice was the best of the sound stimuli. Sound was eliminated from consideration as a possible driving device because of the possible effects on other livestock in the market other than those being driven and its irritation and possible painful effect to humans in the market area. Air blasts were considered a relatively good driving stimulus but were less effective than the mechanical sweep with electrically charged bars. The results of the experiments with the mechanical sweep with electrically charged bars were considered sufficiently favorable to proceed with construction and testing of a prototype driving device.

C. Developing an Automatic Driving and Penning System for Livestock Markets

A contract was negotiated with the American Research and Manufacturing Corporation, Rockville, Md., to design, construct, and test a mechanical driving and penning device for livestock markets based on the results of the research on animal behavioral patterns. At the end of the report year the contractor had submitted design drawings of the device in accordance with the requirements of the contract and was proceeding with construction of the prototype.

D. Developing a Physically Integrated Livestock Marketing and Slaughtering Facility

Due to lack of personnel, no work has been done on this project. Research in this area would draw heavily on the results of previously completed livestock marketing and slaughtering work and would require personnel who had either participated in this work or had gained from other sources a broad and comprehensive working knowledge of the engineering and technical skills needed to carry on this work. Personnel qualified to work on this project have been lost due to transfer or reassignment and it has not been possible to employ suitable replacement personnel to do the work. In view of these circumstances, the project has been discontinued until such time as qualified personnel are available to carry out the work.

E. Layouts and Work Methods for Wool Warehouses

At Hyattsville, Md., a manuscript entitled "Layouts and Work Methods for Wool Warehouses" was completed and submitted for publication. The significant results of this research were covered last year.

F. Layouts and Work Methods for Hotel Supply Houses

At Stillwater, Okla., a draft of a report entitled "Hotel and Restaurant Meat Purveyors--Custom Service Houses--Improved Methods and Facilities" was revised to include suggestions made by industry representatives to make the report of more value to and more easily understood by the operators of hotel supply houses. At the end of the year, the report was in Branch clearance.

A draft of a second manuscript covering frozen portion control hotel supply houses was almost complete at the end of the year. This report covers receiving and storing fresh and frozen primal and boneless cuts of meat, fabricating and packaging steaks and chops, preparing ground meat and forming meat patties, freezing packaged products, casing and storing frozen products, and loading out cased products. The report compares the relative efficiency of the various work methods, and equipment types used in per-

forming inplant operations. Use of the lowest cost methods in a plant handling an average of 75,000 pounds of meat and meat products weekly would reduce labor and equipment costs about $15,500 or 17 percent. Most of the savings are in the labor costs and are due to the use of mechanized equipment such as conveyors, dump-buckets, patty machine feeders, and forklift trucks. An efficient layout was developed based on the lowest cost methods and equipment for this size plant.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

None.

COOPERATIVE MARKETING
Farmer Cooperative Service

Problem: Farmers are expanding their use of cooperative marketing. There are constant changes in transportation, processing, and distribution technology, and in market organization and practices, and changes on the farm itself. In view of these developments, farmer cooperatives and other marketing firms require research results to perform both efficiently and effectively. Such research can assist farmers to maintain and strengthen their bargaining power, increase efficiency, and meet the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a major way for farmers to get maximum returns from their products in the current and rapidly changing market. Farmers own and control cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan, develop, and actually manage the specific marketing program and services that will yield the most for their members. Marketing cooperatives must know what the market demands. They must be able to compute the probable cost of different ways of serving the market. They must understand the possibility of major economies in a well coordinated joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through improved organization, good use of existing plant and personnel, and the selection and use of new equipment and methods.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 23.3. Of this number, 1.0 was devoted to cooperative marketing of citrus, 2.7 to cotton, 4.5 to dairy, 1.2 to deciduous fruit, 2.2 to grain, 3.9 to livestock and wool, 1.3 to oilseeds and peanuts, 1.0 to potatoes, 3.5 to poultry, 0.1 to rice, 0.6 to tobacco, and 1.3 to vegetables.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Dakota, and West Virginia, and by one private research company.

STATE EXPERIMENT STATIONS PROGRAM

The State stations maintain a very broad research program in commodity marketing, the findings of which are valuable to cooperatives and to other marketing firms. There are at this time nine projects in eight States that deal specifically with cooperative marketing. Five projects are commodity oriented and deal with grain, tobacco, milk, livestock, and fruits and vegetables. These projects seek to find out how cooperatives are adjusting or might better adjust to changes in market structure and marketing practices. In some instances researchers are studying the success and failure of cooperatives and the organizational structure. One study of the history of major cooperative marketing associations in the State will be published as a book and will undoubtedly receive nationwide attention.

Because of the growing interest in the role of cooperatives in market structure, one State recently initiated a major project in this area. The project leader views cooperative enterprises as a structural dimension of farm markets. The objectives and operating procedures of cooperatives will be studied to see if they have a unique impact upon market conduct and performance. If so, this may have significant implications for Government policies and programs.

The total research effort on cooperative marketing in the eight States is 3.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Coordination of marketing

Farmers and their cooperatives need to adapt their marketing methods to the requirements of large-scale buyers, mass merchandising, and other changed conditions. In many cases the coordination of marketing of a number of cooperatives, marketing the produce of hundreds or thousands of farmers, will satisfy these needs and improve returns to farmers. Such coordination may be accomplished by establishment of joint sales agencies or by other methods. Research to determine the problems and needs, and to develop guides for adopting new practices, included work with several commodities.

B. Improving cooperative sales and distribution methods

In many commodity fields, wholesale and retail marketing practices have changed so much that sales and distribution methods need to be restudied from the farm level forward. Research on these problems included work in several commodities.

Wool. A study under contract with Iowa State University is evaluating factors influencing wool marketing decisions of Iowa farmers. Wool producers, marketing agencies and wool buyers were surveyed to determine why farmers use various marketing methods. Findings will assist cooperatives in Iowa and other States provide the services best suited to small farm flock owners.

C. Potentials in cooperative marketing

In several commodity areas an appraisal is needed of the present and potential role of cooperative marketing. Current information on cooperative operations can be related to production and marketing conditions. This research will yield suggestions about cooperative operations and services, and provide current data needed by cooperative leaders and others for planning and implementing cooperative marketing programs.

Livestock. Trends in consumption and the market potential for meat in the Northeast were studied on a regional basis. Several concerns were contacted in the region that buy meat for additional processing. Preliminary findings indicate that existing and proposed cooperative slaughter plants in the Corn Belt area could find profitable outlets for their members' livestock in the Northeast.

Studies under contract with Montana, North Dakota, and Oregon relating to cooperative feedlots have been completed. These studies indicate possible benefits to livestock growers and grain producers from feeding locally produced animals and crops over selling both the feeder animals and grain.

D. Pooling and pricing

Pooling principles and procedures must be periodically examined as to their effect on equity among members and efficiency in marketing. In some commodities, pooling has not come into widespread use, and the use of pooling needs to be studied and its application considered.

Wool. A study of over 230 cooperative wool pools showed that these pools provide adequate market outlets for many small wool producers. These pools benefit small flock owners through greater bargaining power and higher prices, convenience, quick cash payments to growers, and educational benefits on ways to prepare their wool and sell on a graded basis.

E. Improving operating methods in processing and storage

Studies were underway in several commodity fields to examine new methods, equipment, facilities, and structures for efficient and safe processing and storage of agricultural products by cooperatives.

Livestock. Three livestock marketing cooperatives were studied to find ways to increase the income of livestock growers by more efficient operation of existing cooperatives.

F. Cost and efficiency

Research studies were undertaken to develop more efficient marketing practices and procedures through analysis of costs involved in using various kinds of facilities and methods of operation.

Livestock. Analysis was made of the feasibility of livestock producer cooperatives integrating their operations from production through feedyards, marketing, processing, and distribution. Information was provided several groups about one or more phases of handling livestock.

Wool. Assistance was provided wool cooperatives in solving their wool handling and marketing problems. Study showed ways for these cooperatives to extend their services and also reduce their operating costs.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Fox, R. L. 1964. Service--The Merit Basis for Livestock and Wool Co-ops. News for Farmer Cooperatives (Jan.).

MARKET POTENTIALS FOR NEW PRODUCTS AND USES
Marketing Economics Division, ERS

Problem: Increased emphasis should be placed on new products and new uses because of their importance in expanding markets and maintaining a high rate of economic growth. Agricultural producers and processors need to take maximum advantage of the opportunities offered with respect to additional outlets for surplus supplies, increased returns, lowered costs, and improved competitive positions relative to non-agricultural products. Continuing evaluations are needed of the commercial feasibility and market potentials of new or improved agricultural products, by-products, and products from new crops in food, feed, and industrial uses; of the economic feasibility of developing new uses and establishing new crops, including appraisal of their impact on present markets; and of the economic and technical requirements of end-uses. Such evaluation will provide a sound economic base for decisions on commercial developments, as well as information to guide further utilization research by physical scientists.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural economists and personnel with dual economic and technical training engaged in research to bridge the gap between laboratory developments and commercial adoption to assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and expanded markets that new products and new uses can afford. Research is carried on in industrial and food uses at Washington, D.C., and six field offices -- agricultural economists are located at each of the four Utilization Research and Development Divisions, New Orleans, Louisiana; Albany, California; Philadelphia, Pennsylvania; and Peoria, Illinois. Economists are also stationed at the Hawaii Agricultural Experiment Station, Honolulu, Hawaii, and at the Department of Agricultural Economics, Clemson University, Clemson, South Carolina.

Research is conducted on animal products, cotton, grain and forages, oilseeds, horticultural crops, new crops, and on impacts of technological innovations. Cooperative research is conducted with the Hawaii Agricultural Experiment Station on Kona coffee and Hawaiian fruits and vegetables, with the Pennsylvania Agricultural Experiment Station on maple products, with the Louisiana Agricultural Experiment Station on a new sweetpotato product, and with Clemson University on market potentials for modified milk. Producer groups, such as the Louisiana Sweetpotato Commission and the Michigan Apple Commission, contribute to studies of potentials of new products pertaining to their area of interest.

The Federal scientific effort devoted to research in this area totals about 19.9 man-years. Commodity-wise, 4.7 man-years are currently devoted to animal products; 3.1 to grains; 2.6 to oilseeds and sugar; 3.9 to horticultural crops; and 5.6 to other research, principally new crops and impact of technological innovations.

PROGRAM OF STATE EXPERIMENT STATIONS

Little, if any, research in economics is carried out in this area by State agricultural experiment station personnel. Much research is being conducted on the development of improved products and uses, but it is in the area of technology.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

The Market for Wurlan Wool. Wurlanized wool developed by WU closely meets requirements for complete launderability needs, as determined in a market study, to enable all-wool apparel to compete more effectively with easy-care fabrics. The study of market prospects for easy-care, all-wool apparel showed that practically all retailers sold easy-care wool blends, whereas only 50 percent of the retailers carried at least one all-wool apparel item with some limited launderability features. Market reactions indicated that the addition of the complete launderability feature to wool's existing functional serviceability and aesthetic features would find broad acceptance and may offer a means to increase market value and sales of many all-wool apparel items. About 131 million pounds of wool presently go into apparel items in which the complete launderability feature could be applied to advantage. From a cost aspect, consumers would soon more than recoup higher initial purchase costs of completely launderable all-wool garments through reduced maintenance costs.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAM

None.

CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--HOUSEHOLD AND INDUSTRIAL

Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for consumers to express to producers either pleasure or displeasure with available merchandise. To market agricultural products more effectively, it is necessary to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on consumers' attitudes toward old and new product forms of agricultural commodities, preferences, levels of information or misinformation, satisfactions or dislikes, and what product characteristics would better satisfy current consumers and/or attract new ones. It is also important to know the relationship between the consumption of one agricultural commodity and another in consumers' patterns of use, the relationship between agricultural and nonagricultural products, and probable trends in the consumption of farm products. Producer and industry groups as well as marketing agencies consider such information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increases returns to growers.

USDA PROGRAM

The Special Surveys Branch conducts applied research among representative samples of industrial, institutional, or household consumers and potential consumers. Such research may be conducted to determine preferences, opinions, buying practices, and use habits with respect to various agricultural commodities; the role of competitive products; acceptance of new or improved products; and consumers' ability to discriminate among selected attributes of a product or levels of an attribute, and the preferences associated with discriminable forms.

In addition to the studies of consumer preference and discrimination, the Branch also provides consultants and conducts special studies, upon request, for other agencies in the USDA or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The research is carried out in cooperation with other USDA or federal agencies, State experiment stations, departments of agriculture, and land grant colleges, and agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology or other social sciences, in Washington, D. C., which is headquarters for all the research whether it is conducted under contract or directly by the Branch. The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years. An additional .2 professional man-year was devoted to research conducted under a transfer of funds arrangement.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Consumer Preference

Fibers in wearing apparel. The rapid expansion in recent years in the use of manmade fibers and blends necessitates up-to-date evaluations of consumer reactions to natural fibers in specified end uses. Such data give industry a better understanding of its markets, and provide a guide for planning physical science research on product improvement as well as educational, promotional, and merchandising efforts designed to strengthen the market position of cotton and wool.

A contract has been signed with a market research firm for a nationwide survey among women to provide current information on their experiences, beliefs, attitudes, and complaints related to natural and competing fibers in selected items of clothing. The Department and the cotton and wool industries, in an effort to meet the increasing competition from manmade fibers, have developed new forms of materials in recent years (for example: improved wash-and-wear, wrinkle resistant, permanently creased, and stretch cotton; and machine-washable and permanently creased wool); consumer reactions to these new developments will also be assessed.

A preliminary report on the results of a contract study of reactions to fibers in clothing among a nationwide sample of teenage boys and girls will be issued during the Fall of 1964; a final report presenting more detailed findings is in preparation.

The preliminary results indicate that wool was the leader in ownership and preference for winter skirts, boys' sport coats, and boys' and girls' sweaters and outer short coats. Warmth was the main attraction of wool, although its ability to withstand wrinkles, to hold its shape, and its soil resistance were also frequently mentioned as reasons for preferring it over other fibers. Cotton was the leader in summer clothes for both boys and girls. It was the winter favorite as well among boys for everyday pants and sport shirts and among girls for everyday dresses and blouses. Comfort was the main attraction of cotton, winter or summer; that is, it did not irritate the skin, it was cool in the summer, and warm enough or not too warm in the winter. In addition, girls stressed the ease of washing and ironing cotton as a reason for preferring it over other fibers.

Cotton-polyester was important in summer wear for girls and boys. The teenagers who preferred it gave, for the most part, the same reasons for their preference as those who chose cotton. However, cotton-polyester had the added attraction that it did not wrinkle. Nylon was the most frequently owned and preferred fiber for girls' slips and half-slips, mainly because of the ease in care and laundering. Acrylic fibers were important, after wool, either alone or in blends, in winter sweaters. Those who preferred acrylic in sweaters did so because it did not irritate the skin, held its shape, and, of especial importance to girls, could be easily washed.

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Division, ERS

PROBLEM

Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of frequent accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. It is a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry. This is accomplished through a continuous flow of current outlook information, the development of longer range projections of the economic prospects for agricultural commodities, and analyses of the economic implications of existing and proposed programs affecting farm commodities.

USDA AND COOPERATIVE PROGRAM

The program includes the regular publication of 12 commodity outlook reports; holding of the Annual Outlook Conference in Washington in mid-November; participation of commodity specialists at regional and State outlook meetings and at meetings of farm organizations and agricultural industry groups; preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities; issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities; long-range projections of supply of and demand for the major agricultural commodities; and continuing analysis of the impact of existing and proposed alternative farm programs as they affect output, utilization, and prices of these commodities.

Except for a Regional Field Office for Livestock, in Denver, Colorado, all the USDA situation and outlook work is carried on in Washington. The regional livestock project is a cooperative effort including the Economic and Statistical Analysis Division, the Federal Extension Service, and State Extension Services in the Western and certain Great Plains States.

The total USDA commodity situation and outlook program currently involves 21.5 professional man-years.

(a) Livestock and Meat. This work involves 2.5 professional man-years in Washington and 2.0 professional man-years in Denver, Colorado. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of livestock and meats. These appraisals, developments of interest to the industry, and results of special studies

are published 6 times a year in regular issues of the Livestock and Meat Situation, in special additional issues as warranted, quarterly in the Demand and Price Situation and the National Food Situation, and monthly in the Western Livestock Round-Up, which is supplemented by special releases and materials circulated to Extension Marketing Specialists in the cooperating Western and Great Plains States. A comprehensive analysis of the livestock situation is presented at the Annual Outlook Conference. Outlook appraisals are presented at regional and State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special analyses are prepared on the probable effect of proposed feed grain programs on the price, supply and consumption of livestock and livestock products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Livestock and Meat Statistics is published annually.

(b) Fats and Oils. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals, developments of interest to the industry, and results of special studies are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation and the National Food Situation, and occasionally in monthly issues of the Farm Index and the Agricultural Situation. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference, and more limited appraisals are given at meetings with industry groups. Special analyses are prepared on the probable effect of proposed programs on the acreage, price, supply, and demand for oilseed crops and for fats and oils and their products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Oils, and Their Products, 1909-63, is being revised and updated for publication in the fall of 1965.

(c) Wool. This work involves 1.5 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of wool and other animal fibers. These appraisals are published four times a year in the Wool Situation and in the Demand and Price Situation. Outlook appraisals are presented at the National Agricultural Outlook Conference, at regional or State meetings, at meetings of farm organizations, and to various industry groups. Special analyses are prepared on the probable effect of proposed programs on the price, supply, and consumption of wool and wool textile products. Basic statistical series are developed, maintained, and improved for general use in statistical and economic analysis. A Statistical Handbook, Wool Statistics and Related Data, is published annually.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

Four States have projects that deal specifically with analysis of current price trends and prediction of future prices. There is increasing interest in longer range price prediction because of the growing specialization of farms, which make yearly enterprise shifts less common and less feasible, and which calls for large capital commitments over longer periods of time.

The total direct research effort in the situation and outlook area is approximately 1.7 professional man-years. While not designated as outlook research, much of the research conducted by the experiment stations and reported elsewhere contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Livestock and Meat

In addition to the regular situation and outlook work, several special analyses were made. Attention was given to the cattle cycle which began its current buildup phase in 1959. Major factors considered were the length of the various cycles, the rate of buildup, and the effects of increased feedlot feeding on the present cycle. An analysis was made of average live weights of slaughter cattle and the relative price differentials between grades as steer and heifer beef production is increased. With the movement toward larger cattle feeding operations, an evaluation was made of the significance of changing seasonal placement patterns. Because of relatively low prices, particularly for fed cattle, special analyses were made of alternative USDA purchase programs and their effects on price and producer returns.

A study was made of U.S. foreign trade in livestock and livestock products, and results were published in the May issue of the Livestock and Meat Situation report.

Further attention was devoted to appraising the profitability of alternative feeding programs--short fed versus long fed. In addition, an analysis was made of the hog-corn price ratio through time. This analysis indicated that as labor and other costs advance the ratio is becoming a less reliable indicator of farrowings than in earlier years.

B. Wool

The U.S. wool industry during 1964 experienced a further decline in sheep numbers, lower wool production, moderately smaller mill consumption of apparel and carpet wool, a shift in wool use to lower quality wools, and a decline in imports of raw wool and wool textile products. In contrast to this lower production and use of wool, more man-made fibers were produced and their use on the woolen and worsted systems increased significantly. Domestic wool prices, however, averaged above those of a year earlier due to firm demand for foreign wools in world markets.

World wool supplies in the 1963-64 marketing season were moderately less than in the previous season. Lower stocks held by dealers and manufacturers offset the record high production. Demand for wool continued firm as consumption exceeded production for the fourth consecutive season. This resulted in increasing wool prices to the highest levels since 1957. The expanding market for wool products has led the wool industry to use other fibers--especially man-made fibers--with wool to meet these demands.

Special studies were made relating to foreign trade in raw wool and wool textile products and their impact on the U.S. wool industry. The analysis included the probable impact on the incentive payment program of the National Wool Act if reductions were made in the duties on wool and wool products. There likely would be a decline in U.S. wool prices, less duty collected, larger payments made to wool growers under current provisions of the program, and the eventual need for a different method of financing the wool program.

Quarterly estimates were provided to the Commonwealth Economic Committee on U.S. mill activity. The data estimated include mill use of raw wool and all other fibers in the woolen and worsted industry, production of wool tops, yarn, and fabric, and stocks of raw wool and tops.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Livestock and Meat

Rojko, A. S. Livestock and Meat Situation. Published 6 times a year. ERS, USDA, Washingtion, D. C.

Rockwell, George R. Jr. May 1964. U.S. foreign trade in livestock and livestock products. Livestock and Meat Situation, pp. 18-38.

Thompson, John W. January 1964. Hide and leather situation brighter in 1964. Livestock and Meat Situation, pp. 26-28

Thompson, John W. July 1964. Recent changes in hide marketings. Livestock and Meat Situation, pp. 34-37.

Livestock and Meat Statistics, August 1964. Supplement for 1963 to ERS Statistical Bulletin No. 333, 162 pp.

Wool

Raymond, Charles E. Wool Situation. Published quarterly. ERS, USDA, Washington, D. C.